PB-240 043

RADIOLOGICAL HEALTH DATA, VOLUME 4, NUMBERS 4-6, APRIL-JUNE 1963

Public Health Service
Washington, D. C.

June 1963

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BIBLIOGRAPHIC DATA SHEET

1. Report No.
RHD 4 (4-6)

2.

PB 240 043

4. Title and Subtitle
Radiological Health Data
Volume 4, Nos 4-6

5. Report Date
Apr-June 1963

6.

7. Author(s)
None

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
U.S. Department of Health, Education, and Welfare
Public Health Service
Washington, D. C. 20201

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address
U.S. Environmental Protection Agency
Office of Radiation Programs
401 M St., S. W.
Washington, D. C. 20460

13. Type of Report & Period Covered
Final: Apr-June 1963

14.

15. Supplementary Notes

16. Abstracts

Data and interpretation of data on radiation exposure to humans and on radioactivity in milk, water, air, and other environmental media are presented.

17. Key Words and Document Analysis. 17a. Descriptors

Radiation
Radioactivity
Air
Water
Milk
Food
Human

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

Reproduced by
NATIONAL TECHNICAL
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US Department of Commerce
Springfield, VA. 22151

PRICES SUBJECT TO CHANGE

18. Availability Statement
Release unlimited

1

19. Security Class (This Report)
UNCLASSIFIED

20. Security Class (This Page
UNCLASSIFIED

21. No. of Pages
166

22. Price PC
6.25
MF
2.25

RADIOLOGICAL HEALTH DATA

VOLUME IV, NUMBER 4
APRIL 1963

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SECTION I.—AIR AND FALLOUT

Fission Product Beta Activity in Airborne Particulates and Precipitation

Quick and sensitive detection of fission product activity fluctuations in the environment is possible through a program of continuous surveillance of gross beta activity in air and precipitation. The information obtained through surveillance does not alone permit evaluation of biological effects due to fallout but it does form the basis of alerting systems and can be used as a rough guide to when and where more extensive monitoring of radioactivity in food, milk, and water is necessary.

December 1962 gross beta concentrations are presented here in reports from the Radiation Surveillance Network, 80th Meridian (West) Sampling Program, Canadian Radioactive Fallout Study Program, and the Mexican Radioactive Fallout Program. Data from the National Air Sampling Network for fourth quarter 1962 and from the National Committee for Nuclear Energy in Rome, Italy for all of 1961 are also presented. Because of differences in equipment and techniques, the results of one network's surveillance are not directly comparable with those of another. However, intercalibration factors for comparing the results of three networks have been determined in a study conducted by Lockhart and Patterson of the U.S. Naval Research Laboratory (*1, 2*). Using these factors, a 1.00 $\mu\mu c/m^3$ reading by the Canadian Air Monitoring Network would correspond to a 0.65 $\mu\mu c/m^3$ reading by the Radiation Surveillance Network and a 1.12 $\mu\mu c/m^3$ reading by the NRL 80th Meridan Network (*2*). These intercalibration factors are subject to the uncertainty of air volume measurements and may not be expected to hold for very young fission products.

REFERENCES

(*1*) Lockhart, L. B., Jr., and R. L. Patterson, Jr.: *Intercalibration of Some Systems Employed in Monitoring Fission Products in the Atmosphere, NRL Report 5850*, Washington, D.C. (November 13, 1962).

(*2*) Lockhart, L. B., Jr., and R. L. Patterson, Jr.: Intercalibration of Some Air Monitoring Systems, *Radiological Health Data*, *3*:466–70, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (December 1962).

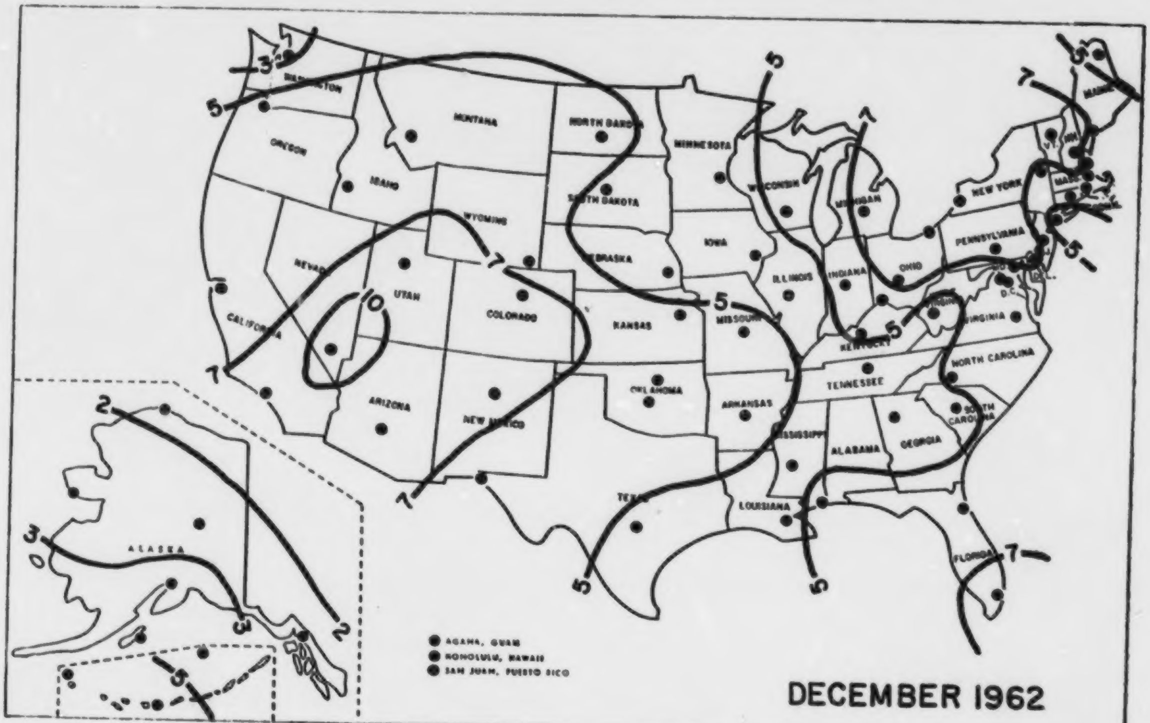
RADIATION SURVEILLANCE NETWORK
December 1962

Division of Radiological Health,
Public Health Service

The Radiation Surveillance Network (RSN) comprises 72 sampling stations distributed among the fifty States, Guam, and Puerto Rico (see figure 1). These stations are manned predominantly by State Health Department personnel.

Air

Daily 24-hour air samples are collected by a high-volume air sampler with a 4-inch diameter carbon-loaded cellulose dust filter. Field estimates of the gross beta activity of airborne particulates are derived by comparing portable


DECEMBER 1962
AGANA, GUAM
HONOLULU, HAWAII
SAN JUAN, PUERTO RICO
ALASKA
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MISSISSIPPI
MICHIGAN
INDIANA
KENTUCKY
TENNESSEE
ALABAMA
OHIO
GEORGIA
FLORIDA
PENNSYLVANIA
NEW YORK
VIRGINIA
NORTH CAROLINA
SOUTH CAROLINA
MAINE
D.C.
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3
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FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS AND AVERAGE FISSION PRODUCT BETA CONCENTRATIONS IN AIR ($\mu\mu c/m^3$)

survey meter readings of these filters with readings taken from a Sr^{90}–Y^{90} known activity source. This determination is usually made about 5 hours after end of collection to eliminate interference from naturally-occurring radon daughters. The Network's station operators contribute to a daily national report by telephoning their field estimates to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C.

The filters are then forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, for a more refined measurement using a thin-window gas-flow proportional counter. Each filter is counted at least 3 days after the end of the sampling period and re-counted 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. The two counts, separated by a 7-day interval, are used to estimate the age of fission products and to extrapolate the activity to the time of collection. The extrapolation is performed by using the Way-Wigner formula ($AT^{1.2}$ = constant)* The daily concentrations and estimated age are reported by the Public Health Service (*1*).

The average fission-product beta concentrations in surface air during December 1962, as determined by laboratory analysis and extrapolated to the time of collection, are given in table 1 and presented by means of concentration contours in figure 1.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis using funnels with collection areas of 0.4 m^2. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory to be counted by the same method used for analyzing the air samples. If the collected sample is between 200 and 500 ml, the entire sample is evaporated; if less than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation

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* In this expression, A is the activity and T is the time after fission product formation.

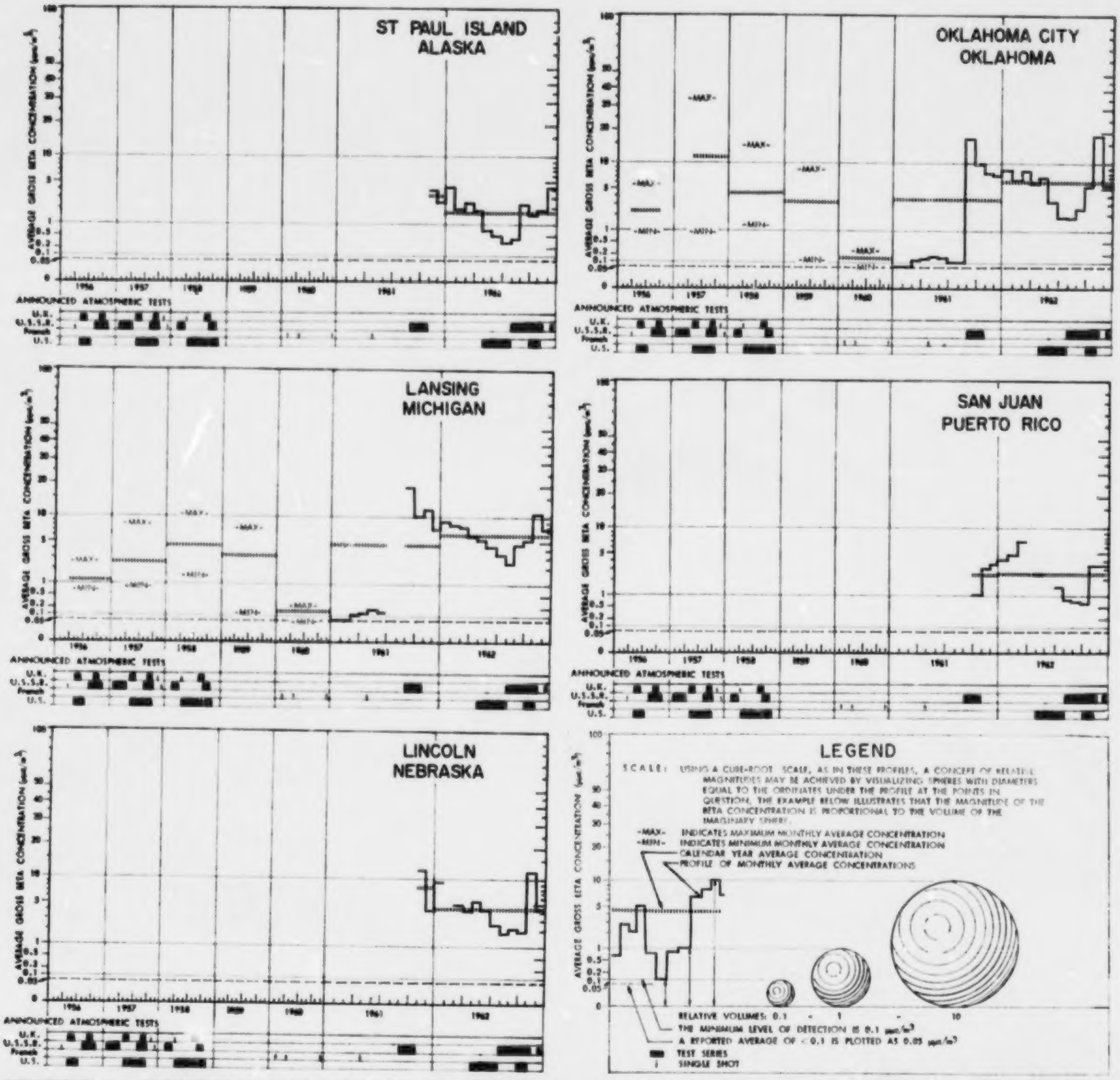

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR, RADIATION SURVEILLANCE NETWORK, 1956–DECEMBER 1962

is reported, but no analysis is made. December 1962 averages of gross beta activity in precipitation, expressed in micromicrocuries per liter (µµc/liter) and millimicrocuries per square meter (mµc/m²), are presented in table 2.

Profiles

Profiles of the monthly average fission product beta activity in airborne particulates for each RSN station covering the period of time from the formation of the network in 1956 to the end of 1960 were published in *RHD*, July 1961. Profiles of 5 stations, updated through December 1962, are shown in figure 2. An index to the *RHD* issue having the most recent profile for each station is given in the last column of table 1.

REFERENCE

(*1*) Radiation Surveillance Network: *Monthly Tabulation of Findings*, Division of Radiological Health, Public Health Service, Washington 25, D.C. (Distribution by Official Request).

TABLE 1.—GROSS BETA ACTIVITY OF PARTICULATES IN AIR, RSN, DECEMBER 1962

[Concentrations in μμc/m³]

Station location	Number of Samples	Maximum	Minimum	Average[a]	Last profile in RHD
Alaska: Adak	31	17	0.18	5.2	Nov. 62
Anchorage	25	8.8	0.49	3.6	Jul. 62
Attu	31	12	<0.10	5.1	Dec. 62
Fairbanks	23	4.6	1.3	2.4	Aug. 62
Juneau	26	5.1	0.19	2.2	Sep. 62
Kodiak	26	15	<0.10	3.3	Oct. 62
Nome	26	9.0	0.36	2.6	Feb. 63
Point Barrow Island	1	1.9	1.9	1.9	Mar. 63
St. Paul Island	15	11	2.1	4.2	Apr. 63
Ariz: Phoenix	28	21	3.8	8.8	Aug. 62
Ark: Little Rock	31	12	0.57	5.9	Sep. 62
Calif: Berkeley	26	17	0.87	5.1	Sep. 62
Los Angeles	19	33	2.6	8.9	Feb. 63
Colo: Denver	25	20	2.3	8.2	Oct. 62
Conn: Hartford	26	17	1.1	6.0	Sep. 62
Del: Dover	19	29	2.0	9.1	b
D.C: Washington	31	26	0.72	5.4	Mar. 63
Fla: Jacksonville	26	15	0.40	6.8	Sep. 62
Miami	26	19	2.9	7.6	Feb. 63
Ga: Atlanta	28	13	0.17	4.0	Jul. 62
Guam: Agana	—	—	—	—	Mar. 63
Hawaii: Honolulu	28	16	0.56	3.4	Nov. 62
Idaho: Boise	31	14	1.8	6.8	Dec. 62
Ill: Springfield	29	11	0.26	4.9	Oct. 62
Ind: Indianapolis	21	28	1.9	5.3	Jul. 62
Iowa: Iowa City	30	12	1.7	4.3	Nov. 62
Kans: Topeka	26	16	2.5	5.7	Jul. 62
Ky: Frankfort	24	19	1.6	5.1	Mar. 63
La: New Orleans	26	10	0.29	4.5	Nov. 62
Maine: Augusta	30	30	0.80	7.0	Mar. 63
Presque Isle	11	14	1.3	4.8	b
Md: Baltimore	18	18	1.7	6.2	Sep. 62
Rockville	13	13	1.4	5.8	b
Mass: Lawrence	31	19	0.95	5.6	Aug. 62
Winchester	25	30	1.8	9.0	b
Mich: Lansing	30	25	1.2	7.8	Apr. 63
Minn: Minneapolis	28	14	1.3	4.0	Mar. 63
Miss: Jackson	27	10	0.28	4.4	Mar. 63
Pascagoula	18	12	0.92	7.0	Nov. 62
Mo: Jefferson City	23	10	1.0	5.2	Dec. 62
Mont: Helena	24	13	1.3	5.7	Nov. 62
Nebr. Lincoln	24	7.3	2.0	4.2	Apr. 63
Nev: Las Vegas	26	48	4.6	12	b
N.H: Concord	16	18	1.8	8.9	b
N.J: Trenton	31	30	1.5	6.7	Oct. 62
N.Mex: Santa Fe	29	22	1.1	7.1	Dec. 62
N.Y: Albany	26	25	1.1	6.8	Jul. 62
Buffalo	25	24	0.26	7.3	
New York	14	8.5	0.62	3.6	Dec. 62
N.C: Gastonia	26	20	0.37	6.2	Oct. 62
N.Dak: Bismarck	29	11	2.5	5.5	Feb. 63
Ohio: Cincinnati	17	10	1.9	5.1	Jul. 60
Columbus	23	32	2.6	8.8	Feb. 63
Painesville	31	30	0.34	8.2	b
Okla: Oklahoma City	29	11	0.41	5.2	Apr. 62
Ponca City	27	6.3	0.32	2.8	Oct. 62
Ore: Portland	27	19	1.3	6.4	Oct. 62
Pa: Harrisburg	23	25	0.55	8.1	Dec. 62
P.R: San Juan	24	7.6	0.70	3.5	Apr. 63
R.I: Providence	26	24	1.9	6.6	Nov. 62
S.C: Columbia	26	14	0.49	4.6	Dec. 62
S.Dak: Pierre	29	8.1	2.0	4.5	Sep. 62
Tenn: Nashville	30	12	0.69	4.9	Feb. 63
Tex: Austin	30	12	0.25	4.9	Aug. 62
El Paso	30	10	3.2	6.0	Feb. 63
Utah: Salt Lake City	31	15	2.2	7.3	Jul. 62
Vt: Barre	30	30	1.2	9.0	b
Va: Richmond	26	24	1.1	5.5	Aug. 62
Wash: Seattle	26	6.3	0.81	2.9	Jul. 62
W.Va: Charleston	26	13	1.1	4.6	b
Wisc: Madison	30	18	1.5	6.3	Aug. 62
Wyo: Cheyenne	30	13	2.1	6.2	Aug. 62
Network average				5.8	

[a] Weighted average obtained by summing the products of individual sampling times and the corresponding activities, and dividing by the summation of the individual sampling times.

[b] Profile is scheduled for a future issue.

TABLE 2.—GROSS BETA ACTIVITY IN PRECIPITATION, RSN, DECEMBER 1962

Station location	Average concentration (μμc/liter)	Total deposition (mμc/m²)
Alaska: Adak	a	—
Anchorage	2,200	7.1
Attu	—	—
Fairbanks	1,500	24
Juneau	1,000	33
Kodiak	—	—
Nome	—	—
Point Barrow Island	—	—
St. Paul Island	—	—
Ariz: Phoenix	—	—
Ark: Little Rock	1,900	77
Calif: Berkeley	460	18
Los Angeles	—	—
Colo: Denver	2,200	3.6
Conn: Hartford	3,500	170
Del: Dover	—	—
D.C: Washington	2,300	160
Fla: Jacksonville	1,000	28
Miami	—	—
Ga: Atlanta	480	7.2
Guam: Agana	—	—
Hawaii: Honolulu	—	—
Idaho: Boise	1,600	11
Ill: Springfield	—	—
Ind: Indianapolis	2,000	21
Iowa: Iowa City	1,900	7.7
Kans: Topeka	2,800	19
Ky: Frankfort	1,800	38
La: New Orleans	1,700	110
Maine: Augusta	1,600	260
Presque Isle	1,200	21
Md: Baltimore	4,900	98
Rockville	—	—
Mass: Lawrence	1,600	170
Winchester	2,300	200
Mich: Lansing	1,800	36
Minn: Minneapolis	1,300	4.1
Miss: Jackson	1,000	43
Pascagoula	—	—
Mo: Jefferson City	1,100	44
Mont: Helena	4,400	30
Nebr: Lincoln	4,200	44
Nev: Las Vegas	—	—
N.H: Concord	—	—
N.J: Trenton	1,800	21
N.Mex: Santa Fe	3,600	63
N.Y: Albany	1,200	55
Buffalo	2,000	110
New York	—	—
N.C: Gastonia	520	39
N.Dak: Bismarck	3,900	17
Ohio: Cincinnati	—	—
Columbus	1,400	50
Painesville	2,600	310
Okla: Oklahoma City	2,900	12
Ponca City	1,800	74
Ore: Portland	2,000	95
Pa: Harrisburg	—	—
P.R: San Juan	480	65
R.I: Providence	3,600	130
S.C: Columbia	1,900	75
S.Dak: Pierre	1,800	4.6
Tenn: Nashville	1,500	36
Tex: Austin	1,500	110
El Paso	2,800	54
Utah: Salt Lake City	2,700	5
Vt: Barre	1,500	110
Va: Richmond	1,900	160
Wash: Seattle	2,100	120
W.Va: Charleston	2,300	120
Wisc: Madison	1,800	28
Wyo: Cheyenne	4,100	1.7

[a] Dash indicates no evaporated sample received.

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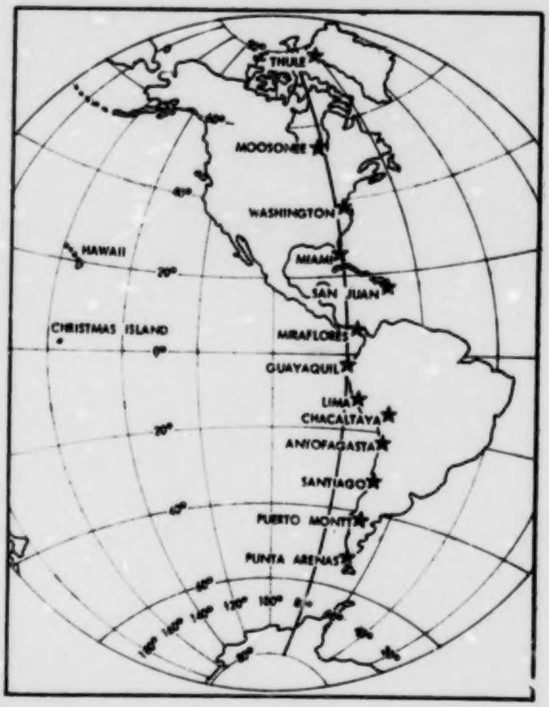
THE 80TH MERIDIAN (WEST) SAMPLING PROGRAM
December 1962

U.S. Naval Research Laboratory

Since 1956 the U.S. Naval Research Laboratory (NRL)* has been making radioactivity measurements of surface air samples collected at various sites (see figure 3) near the 80th Meridian (West). Interested agencies of the United States, Canada, Ecuador, Peru, Bolivia, and Chile participate in the 80th Meridian program by collecting air samples and forwarding them to NRL for analysis. The Division of Biology and Medicine, U.S. Atomic Energy Commission, provides partial financial support for this program.

The sampling procedure involves drawing air continuously for a 7-day period at a rate of approximately 1200 cubic meters per day through an 8-inch diameter, high-efficiency filter, using a positive-displacement blower. After the 7-day period, the filter is removed and forwarded to NRL for assay of gross beta activity. A minimum of 2 weeks after collection is allowed for decay of short-lived radionuclides. December 1962 data in table 3 are not extrapolated to time of collection.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MOOSONEE
WASHINGTON
HAWAII
MIAMI
SAN JUAN
CHRISTMAS ISLAND
MIRAFLORES
GUAYAQUIL
LIMA
CHACALTAYA
ANTOFAGASTA
SANTIAGO
PUERTO MONTT
PUNTA ARENAS
60°
40°
20°
0°
20°
40°
60°
180°
160°
140°
120°
100°
80°

FIGURE 3. — ATMOSPHERIC RADIOACTIVITY SAMPLING STATIONS NEAR THE 80TH MERIDIAN (WEST)

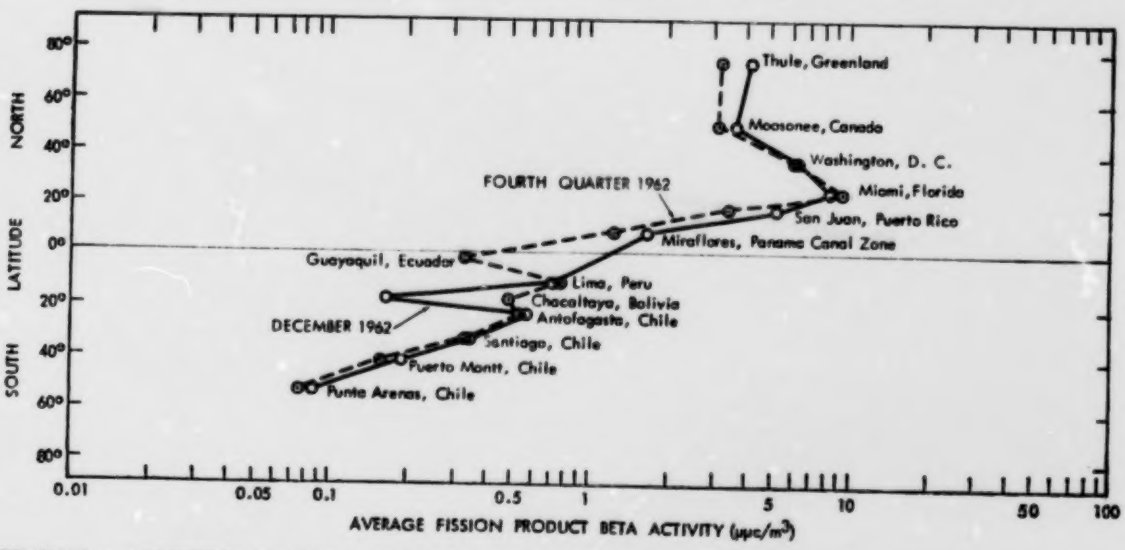

FIGURE 4.—PROFILE OF BETA ACTIVITY, AVERAGE MEASUREMENTS OF SURFACE AIR AT STATIONS NEAR THE 80TH MERIDIAN (WEST), DECEMBER 1962

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[*] *Editor's note:* Effective January 1, 1963, administration of the 80th Meridian (West) Sampling Program was turned over to the Health and Safety Laboratory, Division of Biology and Medicine, AEC, by the U.S. Naval Research Laboratory.

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TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NRL, DECEMBER 1962[a]

[Average concentrations in $\mu\mu c/m^3$]

Day	Punta Arenas, Chile	Puerto Montt, Chile	Santiago, Chile	Antofagasta, Chile	Chacaltaya, Bolivia	Lima, Peru	Guayaquil, Ecuador	Miraflores, Panama Canal Zone	San Juan, P.R.	Mauna Loa, Hawaii[c]	Miami, Florida	Washington, D.C.	Moosonee, Canada	Thule, Greenland
1 2 3	0.050	0.126	0.327	0.477	0.468	[b]—	—	2.034	5.175	5.265	8.730	14.895	6.975	4.995
4 5 6 7 8 9 10	0.126	0.229	0.349	0.429	0.245	—	—	1.026	3.465	4.545	7.665	6.570	2.871	5.445
11 12 13 14 15 16 17 18	0.097	—	0.295	0.664	0.110	0.734	—	1.539	3.465	1.836	11.925	4.590	3.429	4.680
19 20 21 22 23 24 25	—	—	0.407	0.748	0.073	0.814	—	1.346	8.910	3.092	8.100	3.902	3.380	3.537
26 27 28 29 30 31	0.058	0.261	—	0.189	0.112	0.788	—	2.484	4.018	—	5.355	7.020	3.380	2.691
Weighted average	0.088	0.223	0.350	0.572	0.167	0.778	—	1.660	5.220	3.452	8.280	6.435	3.622	4.176

[a] The average concentration determined from a given sample is placed at the center of a rectangle which indicates the length and dates of the sampling period. Station averages for the month were determined by weighting the sample average according to the number of days in the sampling period or that portion of the sampling period occurring in December 1962.

[b] Dash indicates samples were not received.

[c] Mauna Loa data have been included for comparison with Chacaltaya, Bolivia. Both are high elevation stations (3400 and 5200 meters, respectively) and about equally distant north and south of the equator.

NATIONAL AIR SAMPLING NETWORK
Fourth Quarter and Annual Summary 1962

Division of Air Pollution,
Public Health Service

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. The NASN analyzes air samples for the total quantity of suspended particulate matter, benzene soluble organic matter, and gross beta radioactivity. Selected samples are also analyzed for nitrates, sulfates, and a number of metals. These analyses aid in the detection of trends in levels of pollution with respect to time, location, population density, climate, and other factors associated with air quality.

Gross Beta Activity in Air

NASN stations (see figure 5) are manned by cooperating Federal, State, and local agencies. The current basic network consists of 110 sampling stations which operate every year in 73 large cities and 37 nonurban areas. In addition, there are stations in 130 cities which operate every other year. There are 240 sampling stations in all in the NASN network, of which 175 are active in any given year.

At the stations, continuous 24-hour samples of suspended particulate matter are taken. The samples, representing approximately 2,000 cubic meters of air, are collected on glass fiber filters on a biweekly random sampling schedule. They are then sent for analysis to the Network laboratory in Cincinnati, Ohio. Fourth quarter and annual summary 1962 data are presented in tables 4 and 5.

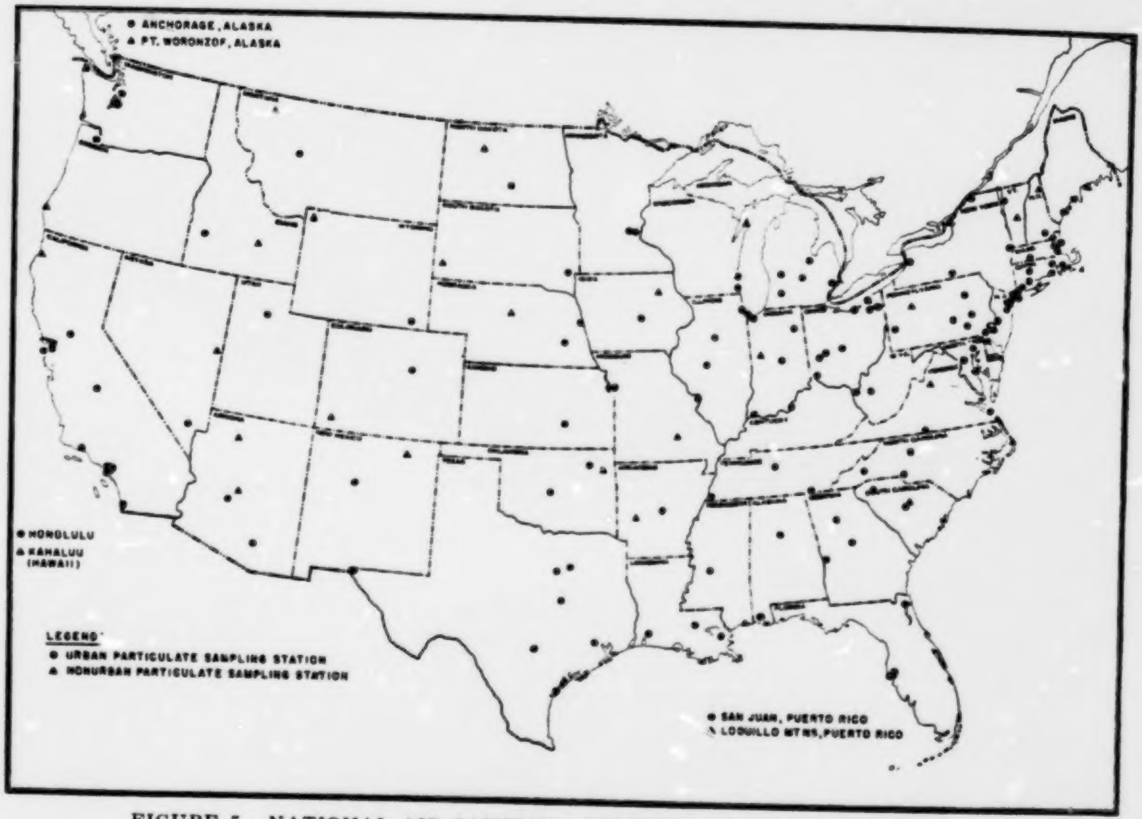
● ANCHORAGE, ALASKA
▲ PT. WORONZOF, ALASKA
● HONOLULU
▲ KAHALUU (HAWAII)
LEGEND:
● URBAN PARTICULATE SAMPLING STATION
▲ NONURBAN PARTICULATE SAMPLING STATION
● SAN JUAN, PUERTO RICO
▲ LUQUILLO MTNS, PUERTO RICO

FIGURE 5.—NATIONAL AIR SAMPLING NETWORK SAMPLING STATIONS, 1962

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TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NASN, FOURTH QUARTER 1962

[Concentrations in pc/m³]

Station location	Number of Samples	Minimum	Maximum	Average
Ala:				
Birmingham	6	1.8	10.0	5.5
Mobile	5	4.9	15.4	10.6
Alaska:				
Anchorage	6	2.5	5.2	4.1
Pt Woronzof*	7	0.7	8.2	3.2
Ariz:				
Grand Canyon Pk*	6	2.2	9.1	5.9
Maricopa Co*	6	3.9	16.7	9.0
Phoenix	5	3.7	10.8	8.4
Tucson	6	4.2	10.2	7.1
Ark:				
Little Rock	5	1.0	10.4	5.8
Montgomery Co*	6	0.6	20.0	7.0
Calif:				
Burbank	7	2.7	16.4	8.1
Fresno	6	2.0	12.0	5.3
Humboldt Co*	4	0.3	7.6	3.0
Los Angeles	6	3.9	15.1	7.6
Oakland	6	2.2	16.8	7.1
Pasadena	6	4.3	31.2	10.6
Richmond	6	0.5	6.6	3.3
Sacramento	6	0.7	6.1	2.8
San Diego	6	2.6	18.7	8.0
San Francisco	6	1.8	13.6	5.2
Santa Barbara	6	3.6	11.5	6.8
Colo:				
Denver	6	1.9	17.0	5.8
Montezuma Co*	7	1.4	17.8	8.9
Conn:				
Bridgeport	6	4.6	12.3	8.1
Hartford	6	2.1	9.1	5.4
New Haven	7	2.1	10.1	5.4
Stamford	6	1.4	7.7	4.9
Del:				
Wilmington	5	3.4	12.8	7.2
D.C:				
Washington	5	1.7	11.0	6.2
Fla:				
Florida Keys*	6	4.4	11.7	7.3
Jacksonville	7	0.4	21.4	9.4
Orlando	6	3.9	33.0	15.9
St. Petersburg	5	4.8	21.6	10.4
Tampa	5	2.3	18.3	9.0
Ga:				
Atlanta	5	3.5	18.2	9.6
Columbus	7	1.6	14.9	8.0
Macon	6	4.4	8.1	5.9
Hawaii:				
Honolulu	6	2.1	11.1	4.9
Kahaluu*	6	2.3	16.8	5.6
Idaho:				
Boise	6	3.4	18.5	9.6
Butte Co*	4	2.1	14.4	8.3
Ill:				
Chicago	6	3.5	12.7	7.1
Cicero	2	4.2	9.0	6.6
Peoria	5	2.1	11.1	6.7
Springfield	5	3.2	10.5	6.5
Ind:				
East Chicago	4	1.5	15.7	7.7
Evansville	7	1.6	8.1	4.7
Fort Wayne	5	3.2	15.1	6.5
Gary	4	2.6	4.0	3.7
Indianapolis	6	1.0	10.1	5.7
Parke Co*	6	3.7	10.7	8.1
Iowa:				
Delaware Co*	6	1.2	12.6	5.9
Des Moines	6	0.9	7.3	4.0
Kans:				
Kansas City	5	2.4	12.7	5.5
Wichita	7	3.1	12.4	7.9
Ky:				
Louisville	3	2.3	9.7	6.0
La:				
Baton Rouge	5	4.4	21.0	9.0
Lake Charles	6	2.4	40.5	14.1
New Orleans	6	1.4	19.4	8.5
Maine:				
Acadia Nat Park*	6	1.6	9.2	4.2
Portland	7	2.7	15.8	6.2
Md:				
Baltimore	6	2.7	6.4	4.9
Calvert Co*	5	1.2	12.1	5.6
Mass:				
Boston	6	1.1	14.1	5.8
Fall River	5	2.4	13.4	7.5
Lawrence	5	1.0	14.0	5.3
Lynn	4	2.7	18.1	7.1
Quincy	6	2.3	19.8	10.4
Somerville	7	2.4	19.3	7.6
Springfield	7	4.5	10.9	6.8
Mich:				
Detroit	6	1.8	8.5	4.8
Grand Rapids	5	0.4	4.4	2.2
Kalamazoo	5	4.0	14.0	7.2
Lansing	6	0.2	12.4	4.6
Saginaw	6	0.3	8.9	4.2
Minn:				
Minneapolis	6	3.7	7.9	5.5
St. Paul	6	1.4	10.1	6.3
Miss:				
Jackson	7	1.7	12.5	6.2
Jackson Co*	4	0.4	8.2	4.5
Mo:				
Kansas City	5	3.4	18.0	7.4
Shannon Co*	5	4.0	10.3	8.1
St. Louis	6	2.0	12.4	7.1
Mont:				
Glacier Nat. Pk*	5	2.0	9.5	6.1
Helena	6	4.1	11.1	7.3
Nebr:				
Lincoln	7	1.1	16.7	8.2
Omaha	6	3.4	19.6	11.0
Thomas Co*	7	1.6	14.2	7.5
Nev:				
Las Vegas	6	5.8	24.0	13.1
White Pine Co*	5	5.2	21.0	11.9
N.H:				
Coos Co*	4	3.6	8.3	7.0
N.J:				
Camden	6	4.1	27.3	11.4
East Orange	7	0.4	11.4	3.5
Elizabeth	6	1.5	14.6	5.9
Newark	7	2.0	8.7	5.5
Trenton	6	1.8	20.0	7.2
N.Mex:				
Albuquerque	7	4.2	16.0	7.6
Colfax Co*	7	4.8	16.4	7.7
N.Y:				
Cape Vincent	5	5.6	9.9	7.2
Glen Cove*	5	3.4	10.8	5.7
Massena	6	0.7	9.2	4.4
New York City	6	1.1	13.0	7.2
Niagara Falls	2	2.8	6.4	4.6
Rochester	6	0.6	8.7	4.5
Troy	6	1.2	7.7	4.8
N.C:				
Asheville	6	1.7	18.4	8.1
Cape Hatteras*	4	7.0	29.0	13.3
Charlotte	6	3.5	9.4	7.4
Winston-Salem	6	1.0	18.1	7.3
N.Dak:				
Bismarck	5	2.5	29.8	11.4
Ward Co*	5	5.0	20.1	8.8
Ohio:				
Akron	6	3.0	7.5	5.4
Cincinnati	5	2.7	7.2	4.2
Cleveland	5	3.7	6.8	5.3
Columbus	5	1.6	14.8	6.3
Dayton	5	2.3	9.3	5.7
Lorain	6	1.5	15.5	6.5
Springfield	6	2.0	12.5	6.5
Toledo	7	0.7	12.3	4.4
Youngstown	7	2.5	12.2	6.6
Okla:				
Cherokee Co*	6	0.5	15.3	6.8
Oklahoma City	6	0.4	11.1	7.1
Tulsa	5	2.6	24.5	8.9
Ore:				
Curry Co*	4	0.6	7.0	3.6
Portland	4	1.8	15.1	6.9
Pa:				
Clarion Co*	4	4.5	7.0	6.1
Harrisburg	5	3.3	9.7	6.8
Lancaster	6	1.6	14.4	8.5
Philadelphia	6	2.1	11.9	6.6
Pittsburgh	6	2.8	12.5	6.3
Reading	6	2.2	12.2	6.6
Wilkes-Barre	7	2.2	10.0	5.5
P.R:				
Loquillo Mountains*	3	0.6	2.3	1.3
San Juan	5	1.3	3.9	2.4
R.I:				
Providence	7	2.1	7.0	4.1
Washington Co*	6	1.2	3.9	1.9
S.C:				
Columbia	5	2.3	7.6	5.8
Greenville	6	3.6	20.0	9.1
Richland Co*	5	1.9	8.1	5.0
S.Dak:				
Black Hills Forest*	6	3.7	15.7	7.4
Sioux Falls	6	2.3	11.1	6.1

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TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NASN, FOURTH QUARTER 1962—Con.

[Concentrations in pc/m³]

Station location	Number of Samples	Minimum	Maximum	Average
Tenn:				
Chattanooga	6	3.5	8.7	6.2
Memphis	6	3.7	11.8	7.3
Nashville	6	3.7	11.7	7.6
Texas:				
Aransas Co*	6	4.4	15.4	8.4
Corpus Christi	6	1.6	18.6	7.6
Dallas	6	2.1	21.0	8.6
El Paso	6	4.4	15.5	8.9
Ft. Worth	7	1.4	23.0	7.0
Houston	5	0.4	21.0	7.0
San Antonio	6	0.5	13.0	4.5
Waco	6	0.3	91.0	20.1
Utah:				
Salt Lake City	6	7.4	18.6	12.0
Vt:				
Burlington	5	0.9	6.2	4.4
Orange Co*	6	0.9	8.1	4.7
Va:				
Danville	6	1.9	11.9	6.1
Norfolk	5	2.9	9.2	6.6
Shenandoah Nat. Pk*	6	3.8	10.8	6.8
Wash:				
Clallam Co*	4	2.4	9.6	4.9
Seattle	6	1.0	9.8	4.0
Tacoma	6	1.9	5.2	3.7
W.Va:				
Charleston	6	4.2	6.5	5.1
Huntington	4	4.9	7.5	6.2
Wisc:				
Door Co*	6	0.6	14.0	5.3
Milwaukee	6	2.7	18.5	6.6
Racine	6	1.6	15.0	4.7
Wyo:				
Cheyenne	6	3.5	19.3	10.8

* Nonurban Station.

TABLE 5.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NASN, ANNUAL SUMMARY, 1962

[Concentrations in pc/m³]

Station location	Number of Samples	Minimum	Maximum	Average
Ala:				
Birmingham	26	0.3	15.7	7.0
Mobile	25	1.1	16.6	7.6
Alaska:				
Anchorage	25	0.2	11.1	4.1
Pt. Woronzof*	25	<0.1	17.6	4.2
Ariz:				
Grand Canyon Pk*	26	0.5	23.8	9.3
Maricopa Co*	26	0.9	33.8	10.2
Phoenix	25	0.7	21.6	9.7
Tucson	25	2.5	18.2	8.9
Ark:				
Little Rock	23	0.2	15.6	6.5
Montgomery Co*	23	0.3	20.0	5.9
Calif:				
Burbank	22	2.5	20.2	6.7
Fresno	26	2.0	23.3	6.6
Humboldt Co*	19	0.2	9.7	3.0
Los Angeles	24	1.2	20.1	6.6
Oakland	25	0.7	16.8	5.1
Pasadena	23	1.8	31.2	6.8
Richmond	24	0.1	11.5	3.4
Sacramento	26	0.7	19.6	5.2
San Diego	25	0.9	18.7	6.6
San Francisco	26	0.5	25.5	5.6
Santa Barbara	25	0.7	21.4	6.1
Colo:				
Denver	24	1.2	17.0	5.3
Montezuma Co*	25	1.4	17.8	8.6
Conn:				
Bridgeport	25	0.4	13.3	6.4
Hartford	26	0.3	10.3	5.2
New Haven	26	0.9	11.8	5.6
Stamford	26	1.1	11.7	5.0
Del:				
Kent Co*	14	0.3	28.4	6.7
Wilmington	23	0.8	12.8	4.9
D.C:				
Washington	23	1.7	14.0	6.3
Fla:				
Florida Keys*	25	0.5	11.7	5.1
Jacksonville	26	0.4	21.4	6.7
Orlando	11	1.5	33.0	9.6
St. Petersburg	23	1.0	21.6	6.7
Tampa	24	0.6	18.3	7.0
Ga:				
Atlanta	25	0.9	18.2	6.0
Columbus	26	1.5	18.0	7.4
Macon	24	1.7	14.2	5.9
Hawaii:				
Honolulu	26	0.7	11.1	4.0
Kahaluu	25	1.0	16.8	3.9
Idaho:				
Boise	26	2.3	19.0	7.5
Butte Co*	23	2.1	14.4	7.4
Ill:				
Chicago	26	1.1	12.7	5.7
Cicero	19	1.3	10.4	5.5
Peoria	24	1.7	11.1	6.2
Springfield	22	1.9	16.3	6.6
Ind:				
East Chicago	19	1.5	15.7	5.1
Evansville	24	0.2	10.1	4.6
Fort Wayne	25	1.7	15.8	6.1
Gary	22	1.5	12.8	5.4
Indianapolis	26	1.0	12.7	6.3
Parke Co*	26	1.9	11.4	6.9
Iowa:				
Delaware Co*	23	1.2	16.1	6.1
Des Moines	26	0.9	13.1	5.1
Kans:				
Kansas City	24	0.7	12.7	5.5
Wichita	25	1.7	16.2	7.3
Ky:				
Louisville	19	1.8	13.8	5.7
La:				
Baton Rouge	24	1.2	25.7	8.7
Lake Charles	26	0.5	40.5	7.5
New Orleans	26	0.7	19.4	5.9
Maine:				
Acadia Nat. Park*	22	0.2	13.9	5.2
Portland	24	0.9	15.8	5.4
Md:				
Baltimore	26	0.6	16.7	5.7
Calvert Co*	24	0.7	12.1	6.2
Mass:				
Boston	24	1.0	15.2	6.2
Fall River	24	0.1	15.5	7.1
Lawrence	25	0.5	14.3	6.5
Lynn	24	0.8	18.1	5.6
Quincy	21	0.4	19.8	8.4
Somerville	25	0.3	19.3	7.7
Springfield	26	1.1	11.7	5.8
Mich:				
Detroit	25	0.7	12.1	4.8
Grand Rapids	21	0.4	9.2	3.7
Kalamazoo	25	1.8	17.2	6.7
Lansing	25	0.2	12.4	5.4
Saginaw	25	0.3	11.4	5.6
Minn:				
Minneapolis	26	1.8	12.3	5.3
St. Paul	24	1.4	13.8	6.0
Miss:				
Jackson	25	0.8	14.2	6.4
Jackson Co*	19	0.4	15.4	5.5
Mo:				
Kansas City	23	1.4	18.0	6.7
Shannon Co*	22	1.7	20.1	9.7
St. Louis	25	1.9	12.4	6.1
Mont:				
Glacier Nat. Pk*	24	0.4	13.6	4.9
Helena	25	2.4	12.0	7.2
Nebr:				
Lincoln	26	0.9	16.7	6.5
Omaha	25	1.9	19.6	7.2
Thomas Co*	26	1.6	16.3	7.3
Nev:				
Las Vegas	20	2.8	26.0	13.2
White Pine Co*	22	3.5	21.0	9.0

TABLE 5.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NASN, ANNUAL SUMMARY, 1962—Con.

[Concentrations in pc/m³]

Station location	Number of Samples	Minimum	Maximum	Average
N.H:				
Coos Co*	22	1.8	10.0	5.7
N.J:				
Camden	26	1.8	27.3	7.3
East Orange	23	0.4	11.4	4.8
Elizabeth	25	1.4	14.6	5.4
Newark	26	1.8	10.0	5.0
Trenton	22	[illegible]	20.0	6.5
N.Mex:				
Albuquerque	25	1.9	16.0	7.6
Colfax Co*	25	1.4	17.0	7.3
N.Y:				
Cape Vincent	23	1.7	12.8	6.2
Elmira	13	2.8	17.7	6.5
Glen Cove	18	1.1	25.2	6.8
Massena	26	0.7	10.9	4.4
Mt. Vernon	12	5.1	15.7	8.9
New Rochelle	11	1.9	11.1	6.6
New York City	25	1.1	13.0	6.4
Niagara Falls	5	1.5	6.4	3.4
Rochester	26	0.6	14.1	5.4
Troy	23	1.1	20.4	6.6
N.C:				
Asheville	25	1.5	18.4	7.1
Cape Hatteras	23	1.8	29.0	8.5
Charlotte	24	1.2	12.1	7.0
Winston-Salem	26	1.0	19.1	7.8
N.Dak:				
Bismarck	24	1.9	29.8	6.5
Ward Co*	25	2.2	20.1	5.7
Ohio:				
Akron	26	0.7	12.5	5.4
Cincinnati	25	1.9	14.8	5.3
Cleveland	24	1.4	14.0	6.3
Columbus	25	1.6	20.5	7.1
Dayton	25	1.0	13.1	4.6
Lorain	26	1.5	15.5	6.1
Springfield	25	1.5	12.5	6.0
Toledo	26	0.7	12.3	5.8
Youngstown	26	2.2	12.2	6.2
Okla:				
Cherokee Co*	25	0.4	15.4	7.2
Oklahoma City	23	0.4	13.4	6.8
Tulsa	23	0.8	24.5	6.1
Ore:				
Curry Co*	17	0.3	7.2	2.7
Portland	21	0.8	16.2	5.3
Pa:				
Clarion Co*	21	0.4	16.1	5.9
Harrisburg	19	0.3	10.6	5.8
Lancaster	26	0.4	27.0	7.9
Philadelphia	25	0.6	11.9	5.7
Pittsburgh	26	1.7	12.5	6.1
Reading	24	0.3	12.2	6.2
Wilkes-Barre	26	0.4	12.9	5.9
P.R:				
Loquillo Mountains*	20	0.6	9.9	3.6
San Juan	22	0.6	10.5	4.3
R.I:				
Providence	26	0.5	10.7	4.9
Washington Co*	25	0.5	7.8	3.5
S.C:				
Columbia	22	1.7	13.7	7.8
Greenville	26	1.2	20.0	8.0
Richland Co*	23	1.0	12.6	5.9
S.Dak:				
Black Hills Forest*	24	2.1	64.8	9.4
Sioux Falls	22	0.6	11.1	5.5
Tenn:				
Chattanooga	25	0.9	11.2	5.1
Memphis	26	0.7	12.8	6.7
Nashville	26	0.7	20.6	7.3
Texas:				
Aransas Co*	21	0.7	15.4	6.7
Corpus Christi	25	0.8	18.6	6.3
Dallas	24	0.7	21.0	7.9
El Paso	26	0.7	21.0	9.1
Ft. Worth	26	0.7	23.0	5.9
Houston	25	0.4	21.0	5.9
San Antonio	22	0.5	14.7	4.2
Waco	26	0.3	91.0	9.4
Utah:				
Salt Lake City	26	2.6	18.6	8.8
Vt:				
Burlington	21	0.9	11.3	5.4
Orange Co*	26	0.5	11.0	5.5
Va:				
Danville	26	0.8	14.5	7.5
Norfolk	24	0.4	14.9	7.0
Shenandoah Nat. Pk*	26	2.3	12.9	6.9
Wash:				
Clallam Co*	18	0.2	13.1	3.8
Seattle	24	0.5	10.5	3.5
Tacoma	26	0.1	14.3	4.5
W.Va:				
Charleston	25	0.4	11.2	5.9
Huntington	20	0.7	10.7	5.3
Wisc:				
Door Co*	19	0.6	14.0	4.8
Milwaukee	22	1.4	18.5	4.7
Racine	24	1.6	15.0	3.8
Wyo:				
Cheyenne	26	1.8	104.6	12.6

* Nonurban Station.

TABLE 6.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, FOURTH QUARTER 1962

Station		October		November		December	
		pc/liter	nc/m²	pc/liter	nc/m²	pc/liter	nc/m²
Alabama:	Montgomery	—	—	482	61.1	—	—
Florida:	Tampa	—	—	529	22.5	—	—
Louisiana:	Lake Charles	318	21.9	284	31.0	253	24.7
Maine:	Caribou	726	48.6	597	32.8	1,512	57.0
Massachesetts:	Nantucket	342	59.9	233	40.1	1,117	66.1
Michigan:	Sault Ste. Marie	714	36.2	—	—	1,109	51.3
Missouri:	Columbia	326	20.5	—	—	—	—
New York:	Albany	357	58.4	917	36.5	1,544	85.5
North Carolina:	Cape Hatteras	738	42.1	626	194.1	425	79.9
Ohio:	Cincinnati (Airport)	244	14.2	511	24.4	—	—
	Cincinnati (Gest St.)	395	25.7	571	25.9	851	35.8
Pennsylvania:	Philadelphia	—	—	631	65.0	2,203	129.3
South Carolina:	Charleston	146	12.7	772	34.9	—	—
	Greenville	292	25.5	322	32.7	881	70.5
Tennessee:	Nashville	323	16.6	822	60.9	586	23.4
Virginia:	Sterling	—	—	724	87.8	1,055	82.8
Washington:	Tatoosh	571	69.3	702	205.0	715	186.6

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Gross Beta Activity in Precipitation

During 1959 a precipitation collection and analysis program was established by the Weather Bureau Research Station in Cincinnati, Ohio and the National Air Sampling Network. Monthly composite samples of precipitation are collected at 29 stations, which are located at Weather Bureau offices or airports. They are then forwarded to the Network laboratory for analysis.

The laboratory analyzes these samples for total solids and for a large number of metals and nonmetals. In addition, each sample is analyzed for fission product gross beta radioactivity if a sufficient volume of precipitation remains after chemical analyses have been made.

CANADIAN RADIOACTIVE FALLOUT STUDY PROGRAM

December 1962

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program (RFSP), the Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation. Twenty-four RFSP collection stations are located at airports (see figure 6) where the sampling equipment is operated by meteorologists of the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in the Department's reports (*1–2*).

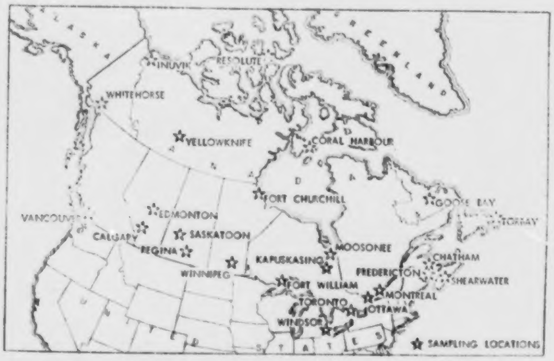

FIGURE 6.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS

Air

In the collection of air samples, about 650 cubic meters of air are drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a disk 2 inches in diameter is removed from each filter and counted with a thin-end-window Geiger flow counter system, calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to allow for the presence of natural activities and for the decay of short-lived fission products. The result is extrapolated to the end of the sampling period. Canadian air data for December 1962 are given in table 7.

TABLE 7.—FISSION PRODUCT GROSS BETA ACTIVITY IN AIR, RFSP, DECEMBER 1962

[Average concentrations in $\mu\mu c/m^3$]

Station	Number of samples	Maximum	Minimum	Average
Calgary	13	30.5	3.5	9.8
Coral Harbour	27	90.0	0.6	9.6
Edmonton	31	13.5	3.0	6.8
Ft. Churchill	29	10.0	0.9	5.1
Ft. William	29	26.0	2.0	9.3
Fredericton	31	20.0	1.2	8.9
Goose Bay	30	14.0	1.6	6.1
Inuvik	31	16.0	2.5	7.8
Montreal	31	40.0	2.1	10.4
Moosonee	30	22.0	1.4	8.7
Ottawa	30	49.0	1.0	12.8
Regina	31	22.0	2.5	8.4
Resolute	20	49.0	2.1	8.7
Saskatoon	31	15.0	2.7	8.4
Sault Ste. Marie	11	23.0	3.5	12.8
Shearwater	30	45.0	0.2	12.3
Torbay	31	40.0	0.5	7.8
Toronto	31	19.5	1.4	9.5
Vancouver	31	15.0	0.3	5.2
Whitehorse	31	10.6	1.6	4.7
Windsor	29	33.0	0.6	12.2
Winnipeg	31	47.0	1.7	5.4
Yellowknife	31	17.0	1.6	8.2
Average	----------	----------	----------	8.6

Precipitation

The amount of radioactive fallout being deposited on the ground is determined from measurements on material collected in special polythene-lined rainfall pots. After transfer of the water to the sampling container, the polythene liner is removed, packed with the sample,

TABLE 8.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, RFSP, DECEMBER 1962

Station	Total beta activity		Deposition of specific radionuclides for selected samples[1,2] (mμc/m²)				
	μμc/liter	mμc/m²	Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ba^{140}
Calgary	2,940	22.4					
Coral Harbour	51,800	224	2.10	0.15	2.88	0.39	0.84
Edmonton	3,170	67.6					
Ft. Churchill	1,160	27.6					
Ft. William	3,340	85.7					
Fredericton	679	73.9					
Goose Bay	982	35.4					
Inuvik	1,450	49.2					
Montreal	1,580	114	9.65	0.33	22.4	0.53	5.36
Moosonee	859	54.5					
Ottawa	1,930	91.6					
Regina	1,800	22.5					
Resolute	3,440	271					
Saskatoon	1,690	37.8					
Sault Ste. Marie	2,320	98.0					
Shearwater	2,050	257					
Torbay	1,385	211	32.7	1.09	42.3	1.48	16.5
Toronto	1,230	72.6					
Vancouver	2,290	456	51.2	1.58	65.5	2.94	22.0
Whitehorse	1,750	74.4					
Windsor	1,550	60.0					
Winnipeg	1,860	19.8	1.22	0.13	1.37	0.14	—
Yellowknife	2,240	29.0					
Average	4,070	107					

[1] All values corrected for decay back to end of collection month.
[2] Values for strontium-90, cesium-137, and zirconium-95 do not include the activities of their daughter isotopes, yttrium-90, barium-137, and niobium-95.

and sent to the laboratory. December 1962 precipitation data for Canada, including some radiochemical analyses, are shown in table 8.

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(3) Mar, P. G.: *Outline of Procedure for the Radiochemical Analysis of Dried Milk Powders for Strontium and Yttrium, CNHW (RPD-5)*, (June 1, 1960).

(4) Beale, J., and J. Gordon: *The Operation of the Radiation Protection Division Air Monitoring Program, CNHW (RPD-11)*, (July 1962).

(5) Booth, A. H.: *The Calculation of Maximum Permissible Levels of Fallout in Air and Water and Their Use in Assessing the Significance of 1961 Levels in Canada, CNHW (RPD-21)*, (August 1962).

Recent Coverage in *Radiological Health Data*:

Period	Issue
Third quarter 1961	*May 1962*
Fourth quarter 1961	*September 1962*
First quarter 1962	*October 1962*
Second and third quarters 1962	*January 1963*
October 1962	*February 1963*
November 1962	*March 1963*

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MEXICAN RADIOACTIVE FALLOUT PROGRAM

December 1962

Radiological Protection Program,
National Commission of Nuclear Energy,
Mexico

The Radiation Surveillance Network of Mexico was established by the "Comisión Nacional de Energía Nuclear" (CNEN) through its Radiological Protection Program (RPP) in 1961 to provide a means for determining increased levels of radioactivity in air and precipitation due to fallout from nuclear tests.

Prior to the establishment of the network, two pilot sampling stations were set up in Mexico City and San Luis Potosí to aid in the selection of equipment and sampling sites. Since April 1962 the network has been expanded to twelve stations, ten of which were in operation by the end of December 1962 (see figure 7).

Seven of the ten sampling stations are located at airports and are operated by airline personnel. The remaining three stations are located at Mexico City, Merida, and Veracruz. Staff members of the RPP operate the station at Mexico City, while the other two stations are manned by members of the "Centro de Previsión del Golfo de México."

Sampling

The sampling procedure involves drawing air 24 hours a day, 3 or 4 days a week at the rate of approximately 1,200 cubic meters per day, through a 6" x 8" high-efficiency glass fiber filter, using high volume samplers. After each 24-hour period the filter is removed and forwarded via airmail to the "Laboratorio de Desechos Radiactivos," CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughters. Data are not extrapolated to time of collection.

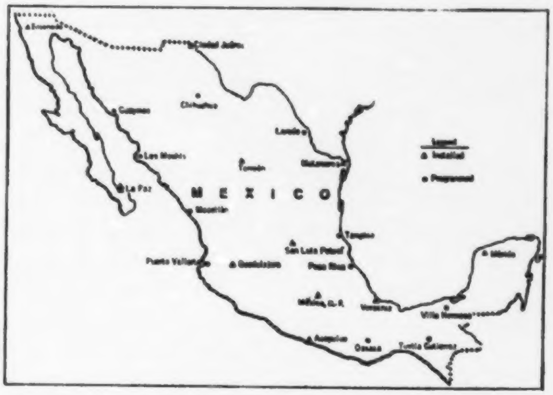

FIGURE 7.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

The maximum, minimum, and average fission product beta concentrations in surface air during December 1962 are presented in table 9.

TABLE 9.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, DECEMBER 1962

[Concentrations in $\mu\mu c/m^3$]

Station	Number of samples	Minimum	Maximum	Average
Acapulco	4	1.3	3.1	2.4
Ciudad Juárez	7	7.1	25.4	16.4
Ensenada	5	3.1	18.5	10.6
Mérida	13	3.3	11.8	8.8
San Luis Potosí	6	2.3	6.8	4.1
Torreón	6	6.0	17.6	11.5
Veracruz	14	0.1	9.3	5.4
Average				8.4

Radioactivity of Surface Air and Fallout, Italy, 1961

Division of Biology and Sanitary Protection
National Committee for Nuclear Energy (Italy)

The Republic of Italy, including the islands of Sardinia and Sicily, compares in latitude with those States ranging from Maine through Virginia in the United States. Comparisons of air and fallout data from the two nations are therefore of some interest.

This review summarizes air and fallout data from selected stations (see figure 1) taken from two semiannual reports (*1*, *2*) of the Comitato Nazionale Per L'Energia Nucleare (CNEN).[a] The selected data originated from 12 cooperating agencies or organizations in addition to CNEN.

Air Sampling

Of the 44 air sampling stations reported by CNEN, 33 were selected for this review because of their uniformity in equipment, materials, and techniques. Continuous daily samples of airborne particulates were collected on 5-cm diameter type SS 589^1 filter paper,[b] with a rate of 100 to 250 m^3/day. The sampler height varied from 1 to 55 meters above ground. Filter gross beta activities were determined 5 days after sampling with end-window G.M. counters calibrated with KCl reference standards. Table 1 presents the monthly average fission product gross beta concentrations in surface air for the 33 selected stations during the calendar year 1961.

Fallout Measurements

Monthly fallout samples (including rain) are collected and analyzed by several different methods. The following 3 methods, representing 30 stations were selected for this review (see table 2).

A. *Rain gage with ion exchange resin.* This device was used at 17 fallout collection stations. The sample is prepared for counting by calcination of the resin.

B. *Cylindrical pot with ion exchange resin.* Nine stations utilized this device for collection of total fallout. In each case preparation of the

TABLE 1.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR IN ITALY, 1961

[Average concentrations in pc/m^3]

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Alghero	<0.05	<0.05	0.06	0.07	0.08	0.09	0.06	0.06	1.4	5.3	7.1	6.8
Ancona	<0.05	0.06	0.07	0.08	0.08	0.09	0.06	0.05	1.9	5.8	8.3	7.3
Bari	<0.04	0.05	0.07	0.07	0.08	0.10	0.06	0.05	3.2	4.8	8.9	4.9
Bologna	0.06	0.05	0.08	0.09	0.11	0.11	0.10	0.07	1.5	5.4	5.0	7.1
Brindisi	<0.05	0.06	0.06	0.09	0.08	0.08	0.07	0.05	5.6	7.4	12	7.9
Casaccia	0.05	0.08	0.10	0.11	0.12	0.14	0.12	0.14	1.4	5.0	8.3	5.5
Catania									3.9	7.0	11	6.7
Cozzo Spadaro	<0.05	<0.05	<0.05	0.05	0.09	0.09	0.05	0.07	3.8	6.8	14	8.3
Elmas	<0.05	0.06	0.07	0.08	0.09	0.09	0.07	0.06	3.1	5.6	9.1	7.5
Ferrania	0.02	0.04	0.06	0.05	0.06	0.06	0.05	0.06	0.72	4.2	3.2	3.0
Genova	0.05	0.06	0.08	0.08	0.09	0.10	0.06	0.07	0.85	5.4	5.7	6.1
Ispra	0.05	0.04	0.07	0.05	0.07	0.06	0.05	0.05	1.6	6.9	7.5	9.3
Messina	<0.05	0.07	0.08	0.11	0.11	0.10	0.08	0.07	3.4	8.0	14	8.7
Milano "A"	0.10	0.10	0.10	0.07	0.07	0.10	0.05	0.05	1.2	3.4	3.0	3.4
Monte Cimone	<0.05	0.06	0.08	0.07	0.08	0.08	0.06	0.05	1.8	5.3	7.4	7.1
Monte Paganella	<0.05	0.06	0.08	0.06	0.07	0.07	0.06	<0.05	1.1	5.8	8.4	9.6
Monte Sant'Angelo	<0.05	0.06	0.06	0.07	0.06	0.06	0.05	<0.05	1.7	4.0	8.3	5.1
Monte Scuro	<0.05	0.06	0.06	0.06	0.10	0.09	0.07	0.05	2.9	6.2	10	7.0
Monte Terminillo	<0.05	0.06	0.06	0.09	0.09	0.09	0.07	0.05	1.5	5.0	7.8	6.7
Napoli "A"	<0.04	0.05	0.07	0.10	0.10	0.09	0.10	0.08	1.9	5.8	11	6.3
Napoli "B"		0.13	0.14	0.15	0.18	0.12	0.10	0.08	1.7	5.9	10	7.3
Palermo	<0.04	0.06	0.06	0.08	0.10	0.09	0.07	0.06	1.9	5.1	8.7	5.0
Pian Rosa	0.06	0.06	0.10	0.09	0.11	0.11	0.08	0.06	1.2	6.3	11	12
Resina	<0.04	0.05	0.07	0.08	0.08	0.09	0.08	0.06	1.8	5.3	10	5.6
Roma (Capannelle)	0.06	0.06	0.09	0.07	0.06	0.08	0.05	0.07	1.3	4.1	7.6	4.6
Saluggia	0.04	0.05	0.10	0.10	0.09	0.08	0.15	0.07	1.0	4.9	3.6	3.7
San Remo	<0.05	0.06	0.08	0.07	0.08	0.08	0.06	0.06	1.0	6.2	6.5	8.9
Tarvisio	<0.05	<0.05	0.06	0.06	0.06	0.06	0.06	<0.05	1.6	4.5	6.1	6.5
Trapani	<0.05	0.06	0.08	0.06	0.08	0.07	0.05	<0.05	1.0	4.6	9.9	—
Trieste	0.06	0.06	0.07	0.07	0.10	0.09	0.08	0.06	2.0	6.0	7.2	6.3
Verbania Pallanza	0.07	0.07	0.08	0.06	0.09	0.07	0.06	0.05	0.91	4.2	5.0	5.9
Verona Villafranca	<0.05	0.06	0.08	0.07	0.06	0.08	0.06	0.05	1.4	4.9	6.0	6.1
Vigna di Valle	0.06	0.07	[illegible]	0.11	0.10	0.10	0.08	0.06	1.6	5.4	9.8	6.7

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[a] National Committee for Nuclear Energy (Italy).

[b] Filter paper SS 589^1 is manufactured by Carl Schleicher and Schuell Co., Germany. It has a fission product retention efficiency of approximately 95 percent.

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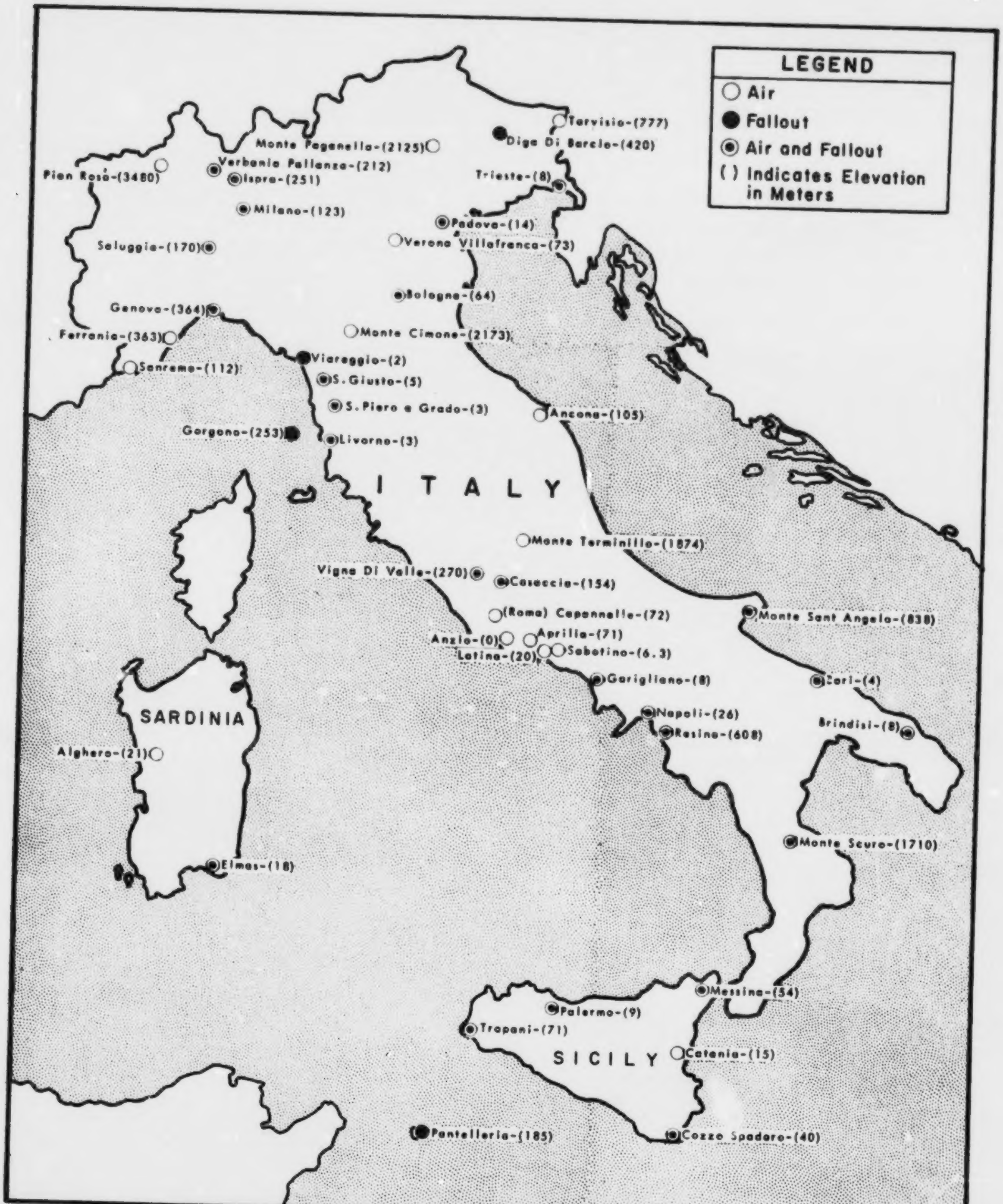
LEGEND
○ Air
● Fallout
◉ Air and Fallout
( ) Indicates Elevation in Meters
Tarvisio-(777)
Monte Paganella-(2125)
Diga Di Barcis-(420)
Verbania Pallanza-(212)
Pian Rosa-(3480)
Ispra-(251)
Trieste-(8)
Milano-(123)
Padova-(14)
Saluggia-(170)
Verona Villafranca-(73)
Bologna-(64)
Genova-(364)
Ferrania-(363)
Monte Cimone-(2173)
Sanremo-(112)
Viareggio-(2)
S. Giusto-(5)
S. Piero a Grado-(3)
Ancona-(105)
Gorgona-(253)
Livorno-(3)
ITALY
Monte Terminillo-(1874)
Vigna Di Valle-(270)
Casaccia-(154)
(Roma) Capannelle-(72)
Monte Sant Angelo-(838)
Anzio-(0)
Aprilia-(71)
Latina-(20)
Sabotino-(6.3)
Garigliano-(8)
Bari-(4)
Napoli-(26)
SARDINIA
Resina-(608)
Brindisi-(8)
Alghero-(21)
Monte Scuro-(1710)
Elmas-(18)
Messina-(54)
Palermo-(9)
Trapani-(71)
SICILY
Catania-(15)
Pantelleria-(185)
Cozzo Spadaro-(40)

FIGURE 8.—AIR AND FALLOUT SAMPLING LOCATIONS IN ITALY

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sample for counting involved incineration of the resins.

C. Cylindrical pot. The cylindrical pot with no ion exchange resins was used at 4 of the stations. Preparation in this case was by evaporation.

Radionuclide Analyses of Fallout Samples

In addition to the gross beta radioactivity of fallout samples, the samples collected at Ispra were analyzed for numerous radionuclides. Monthly deposition of these nuclides are given in table 3.

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(1) Comitato Nazionale Per L'Energia Nucleare: *Data on Environmental Radioactivity Collected in Italy*, BIO/12/61, CNEN (Division of Biology and Health Protection), Via Belisario, 15 Rome (September 1961), Limited Distribution in English-French to UNSCEAR.

(2) Comitato Nazionale Per L'Energia Nucleare: *Data on Environmental Radioactivity Collected in Italy*, BIO/06/62, CNEN (Division of Biology and Health Protection), Via Belisario, 15 Rome (April 1962), Limited Distribution in English-French to UNSCEAR.

TABLE 2.—GROSS BETA ACTIVITY IN MONTHLY FALLOUT (INCLUDING RAIN), ITALY, 1961

[Monthly fallout deposition in nc/m²]

Location	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Rain gage with ion-exchange resins												
Brindisi	0.70	0.29	0.20	1.6	0.38	0.20	0.10	0.14	0.18	37	54	51
Cozzo Spadaro	0.40	0.15	0.77	0.09	0.20	0.22	0.07	0.20	0.19	2.1	23	40
Diga di Barcis	0.64	0.16	0.29	3.6	2.3	8.6		5.4	0.83	145	470	26
Elmas	0.77	0.13	0.10	0.23	0.13	0.88	0.13	0.15	2.4	25	85	35
Garigliano	4.7	3.2	2.7	4.9	7.4	4.0	1.4	2.4	5.1	347	1,102	232
Gorgona				0.55	0.60	0.47	0.14	0.39	4.5	45	75	81
Livorno	1.1	0.43	0.75	0.99	1.4	0.54	0.80	0.47	12	32	88	119
Messina	1.1	0.4	0.9	0.5	0.6	0.5	0.10	0.16	0.58	17	74	123
Monte Sant'Angelo	1.2	0.58	0.17	0.85	1.0	0.52	0.81	0.23	0.10	24	29	25
Monte Scuro	1.5	0.25	0.15	2.7	1.2	0.82	0.39	0.32	0.35	28	88	69
Padova	0.60	1.0	0.53	2.3	2.8	2.5	2.1	0.54	1.3	40	145	100
Pantelleria	0.36	0.20	0.31	0.07	0.41	0.89	0.13	0.29	0.64	20	78	59
S. Giusto	1.2	0.37	0.37	1.1	1.7	0.30	0.28	0.47	1.6	30	108	120
S. Piero a Grado	1.2	0.28	0.24	1.3	1.8	0.42	0.28	0.42	9.0	19	160	116
Trapani	1.4	0.19	0.28	0.20	0.22	0.30	0.07	0.21	0.19	16	73	48
Viareggio	0.80	0.26	0.29	0.35	1.1	0.31	0.10	0.52	10	29	111	62
Vigna di Valle	0.60	0.44	0.43	2.1	0.45	0.36	0.19	0.47	1.7	60	110	74
Cylindrical pot with ion-exchange resins												
Bari	0.86	0.27	0.67	0.86	1.1	1.1	0.55	0.23	0.81	37	74	132
Bologna	0.80	0.29	0.18	2.4	1.5	1.0	1.2	0.39	8.7	50	77	120
Genova	0.52	0.33	0.01	2.1	1.0	1.1	0.58	0.42	22	45	116	64
Milano "A"	0.50	1.3	0.11				0.93	0.11	0.69	18	118	36
Napoli "A"	2.1	0.30	0.97	0.56	0.24	0.50	0.92	0.59	1.1	92	172	129
Palermo	1.9		0.6	4.8	1.4	0.5	9.9	1.4	4.2	75	172	189
Resina	1.2	0.48	0.95	2.4	1.7	1.5	0.43	0.44	0.49	59	225	74
Trieste	1.8	0.29	0.86	2.4	1.7	2.2	2.2	0.30	0.73	58	130	74
Verbania Pallanza	0.28	0.53	0.06	3.3	1.7	3.2	1.3	0.32	7.1	162	83	120
Cylindrical pot only												
Casaccia	1.9	0.56	1.1	2.1	1.9	1.5	0.67	0.45	1.1	204	425	152
Ispra	0.55	0.97	0.17	4.7	2.8	4.1	2.1	0.60	13 *	125 *	149 *	36 *
Milano "C"	0.81	1.7	0.29	3.0	1.9	2.9	2.1	0.88	4.6	58	247	76
Napoli "B"			1.7	1.9	3.4	1.0	0.59	0.68	12	41	181	145

* Values corrected for self-absorption and radioactive decay (with reference to the 15th day of the collection month-22nd day in the case of September): September, 36; October, 510; November, 555; December, 110 nc/m².

TABLE 3.—ANALYSES OF VARIOUS RADIONUCLIDES IN THE MONTHLY FALLOUT SAMPLES COLLECTED AT ISPRA, ITALY, 1961

[Monthly deposition in nc/m²]

Radionuclides	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Sr^{90}	0.06	0.08	0.01	0.70	0.35	0.65	0.16	0.05	0.07	0.59	0.42	0.23
Cs^{137}	0.10	0.14	0.02	1.1	0.60	1.1	0.26	0.09	0.10	0.70	0.47	0.25
I^{131}	--------	--------	--------	--------	--------	--------	--------	--------	--------	10	30	--------
Sr^{89}	--------	--------	--------	--------	--------	--------	--------	--------	1.8	22	29	13
Ba^{140}	--------	--------	--------	--------	--------	--------	--------	--------	7.0	92	78	5
Ce^{141} and Ce^{144}	--------	--------	--------	--------	--------	--------	--------	--------	3.0	48	43	19
Ru^{103} and Ru^{106}	--------	--------	--------	--------	--------	--------	--------	--------	2.0	25	48	11
Zr^{95}–Nb^{95}	--------	--------	--------	--------	--------	--------	--------	--------	2.0	71	102	28

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SECTION II.—FOOD

Radionuclides in Institutional Diet Samples

July–September 1962

Division of Radiological Health, Public Health Service

The determination of radionuclide concentration in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is being administered by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

The program is designed to estimate the dietary intake of radionuclides in a controlled population group ranging from children to young adults of school age. Initially, the program consisted of sampling diets in eight institutions, but it has since been expanded to 21 boarding schools or institutions, geographically distributed as shown in figure 1. Institutions selected range from exclusive, well-funded boarding schools to orphanages with severe economic limitations. Each institution (sampling point) is located in a community monitored by the Pasteurized Milk Network. The analytical data for this program supplement the findings for the Institutional Diet Sampling Program.

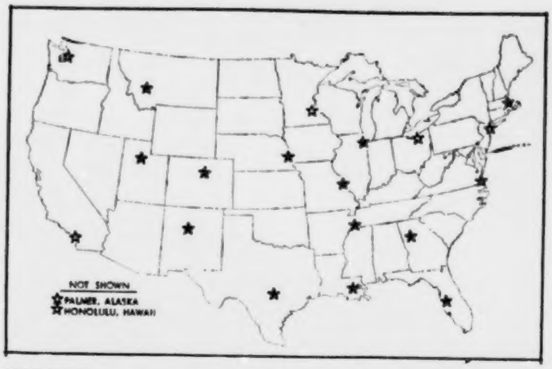

FIGURE 1.—INSTITUTIONAL DIET SAMPLING LOCATIONS, SEPTEMBER 1962

Sampling Procedure

In general, the sampling procedure is the same in each case. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Each institution supplies one complete 7-day, 21-meal diet sample each month. Meals are frozen following collection. On completion of the total sample, it is packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nevada, the Southeastern Radiological Health Laboratory, Montgomery, Alabama, or the Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

Each sample is packaged in three containers: one containing solid food less seed pits, rinds, shells, bones, etc., that would not ordinarily be eaten; one containing dairy products such as milk, cottage cheese, ice cream, etc.; and one containing soft drinks, coffee, tea, etc. A record of the contents of each meal and the approximate weight of each item is recorded by the institution's dietitian and sent with the sample. Samples usually range from 6 to 16 liters in volume and weigh from 8 to 20 kilograms.

Analytical Program

Total weight, stable calcium, and stable potassium determinations are obtained by conventional gravimetric or spectrophotometric methods. Phosphate determinations are made by a colorimetric technique. Because calcium and phosphorus compounds have an effect on the uptake of important boneseeking radionuclides such as strontium-89 and strontium-90 (*2*), they are included in the analytical program.

The radioanalysis program is designed around three basic procedures: (1) gamma spectroscopy, (2) chemical separation of strontium-89 and strontium-90 with subsequent counting, and (3) total radium analysis. In the absence of interferences other than naturally-occurring radioactive potassium (K^{40}), minimum detectable concentrations for the gamma scan on a per-kilogram basis are: I-131, 10 μμc/kg; Cs-137, 5 μμc/kg; and Ba-140, 10 μμc/kg. Approximate minimum detectable concentrations for Sr-89, Sr-90, and total radium are: 5, 1, and 1 μμc/kg, respectively.

Total radium is determined by ashing, separation, and coprecipitation of radium as sulfate or chromate. After a sample is transferred to planchets and dried, its alpha activity is measured by an internal proportional counter with an appropriate delay for checking ingrowth of radium daughters. Since naturally-occurring radionuclides may contribute to the reported total radium values, the total radium technique is a practical screening indicator only. The bone dose, calculated by assuming total radium to be only radium-226, would therefore be moderately high.

Data Treatment

Table 1 presents the dietary intake data expressed on a per-day basis from July 1962 through September 1962 for the 20 institutions from which samples were received. The reported iodine-131 values are based on the iodine-131 content of the sample at the end of the sample collection period. The true iodine-131 intake may therefore be somewhat greater than the reported values.

Certain of the radioanalyses are reported by the laboratories as being "less than" (<) a specified value. For data averaging, the method employed for presentation in table 1 is that all "less-than" data are assumed to be equal to the full "less-than" values as they appear in the column entitled "monthly maximum averages." The column entitled "monthly minimum averages" reflect the averages in which all "less than" values are considered to be 0.

Strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 averages of the institutions' daily intake, as well as announced

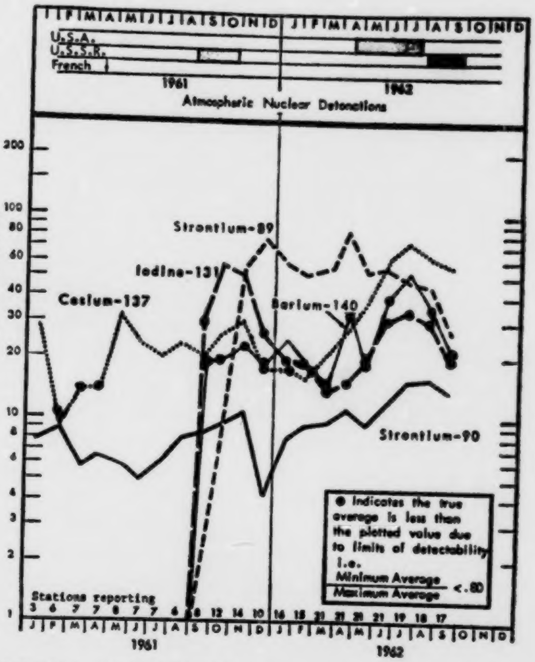

FIGURE 2.—RADIONUCLIDES IN INSTITUTIONAL DIET SAMPLES—AVERAGE OF INSTITUTIONS

atmospheric nuclear detonations for 1961 and 1962, are shown in figure 2. Figure 3 similarly shows the average daily intake of calcium, phosphate, and potassium and total weight of food.

For rapid comprehension, the data are presented graphically in figures 4–11 as station distributions versus daily intake. These are not graphs of continuous functions as might be implied by their appearance. For example, the graph entitled "total intake" of food is divided into six ranges (< 1.00, 1.00–1.49, 1.50–1.99, 2.00–2.49, 2.50–2.99 and 3.00–3.50 kg/day), and the number of institutions in each range is noted and plotted as a bar graph. The maximum of each bar is connected by a smooth curve. This type of construction is used for each month for each item represented in figures 4–11.

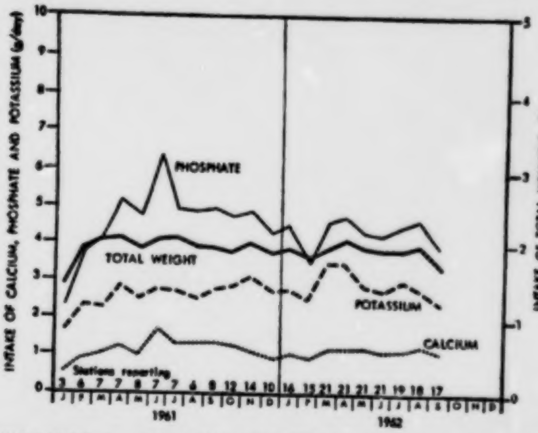

FIGURE 3.—STABLE MATERIALS IN INSTITUTIONAL DIET SAMPLES—AVERAGE OF INSTITUTIONS

Sixteen institutions were used in constructing the graphical distributions and a variation of two institutions or 12.5 percent of the total may not be significant in considering trends in the data.

Discussion of Data

During the 3-month period reported, the dietary intake of strontium–90 ranged between 1 and 42 μμc/day with 39 of 54 institution-months* being in the lowest Radiation Protection Guide (RPG) range. The lowest RPG range established by the Federal Radiation Council is 0 to 20 μμc/day for strontium–90 (*3*, *4*). The May 1962 issue of *Radiological Health Data* contains a discussion of environmental radiation protection standards which should be referred to for an understanding of the RPG (*4*). The strontium–90 distribution (figure 10) has no well-defined peak and is approximately flat between 0 and 25 μμc/day.

The strontium–89 distribution (figure 9) shows that the majority of institutions reported values below 40 μμc/day. The lowest RPG range for strontium–89 is 0 to 200 μμc/day.

The dietary intake of total radium ranged between < 1.0 and 12.0 μμc/day with 93 percent of the institution-months being 6.0 μμc/day or less. Assuming the radium–226 component of the total radium activity to be 30 percent, the intake of radium–226 via the diet probably approaches the top of Range I of the RPG (0 to 2 μμc/day for radium–226) at a few institutions.

Following the resumption of nuclear weapons testing in the atmosphere in 1961, iodine–131 dietary intake increased from nondetectable levels to an institutional high of 228.5 μμc/day (*5*). During the period July–September 1962, the institutional high was 140 μμc/day with only two institution-months being greater than 100 μμc/day. Range II of the iodine–131 RPG is 10–100 μμc/day.

The cesium–137 dietary intake has ranged from < 5 to 225 μμc/day during the period reported. The distribution of institutions (figure 11) does show a peak which extends from 0 to 60 μμc/day. Most institutions have shown a leveling off of the cesium–137 increase that occurred in the second quarter. This can be seen in the average of institutions graph, figure 2.

The distributions of total weight intake of food for this quarter (figure 4) are similar to those for the previous period. The total weight average (figure 3) has usually ranged between about 1.9 and 2.0 kg/day. This average dropped to 1.63 for September 1962, the lowest average noted for the institutional diet sampling program, with the exception of January 1961, when the average of institutions was 1.48.

The calcium intake average of institutions

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* An institution-month is one datum value per institution per month. (e.g., 20 institutions reporting one value per month for 3 months constitutes 60 institution months).

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TABLE 1.—INSTITUTIONAL DAILY DIETARY

Station	Month (1962)	Alaska, Palmer	Colorado, Denver	Florida, Tampa	Georgia, Atlanta	Hawaii, Honolulu	Illinois, Chicago	Louisiana, New Orleans	Massachusetts, Boston	Minnesota, Minneapolis
Total weight (kg/day)	Jul	1.16	2.29	1.77	1.72	1.97	1.36	2.41	1.94	1.52
	Aug	1.20	2.39	1.58	1.50	1.89	1.58	2.51	2.20	1.82
	Sep	1.22	2.10	1.61	1.42	0.60	1.41	1.83	1.87	1.64
Calcium (g/day)	Jul	0.6	1.4	0.9	0.7	0.8	0.9	1.5	1.0	0.9
	Aug	1.0	1.7	0.8	0.8	0.7	1.4	1.6	1.3	1.0
	Sep	0.8	1.5	0.7	0.8	0.2	0.8	1.2	1.5	1.5
Phosphorus as phosphate [1] (g/day)	Jul	2.4	4.4	3.7	3.6	3.7	4.4	5.8	4.8	3.2
	Aug	2.9	6.1	3.5	3.6	3.4	4.7	5.2	5.6	3.4
	Sep	3.5	4.8	2.7	3.3	1.4	3.4	5.0	4.8	3.8
Potassium (g/day)	Jul	1.8	3.9	1.8	2.1	2.6	4.1	2.9	2.7	2.3
	Aug	1.9	4.1	2.1	1.8	2.3	3.2	4.0	3.7	2.4
	Sep	1.5	3.2	2.3	2.0	0.7	4.9	2.7	2.2	1.8
Total radium (μμc/day)	Jul	2.0	1.0	3.4	1.9	12.0	1.0	<3.0	3.0	<1.0
	Aug	1.0	2.0	2.2	1.6	6.0	2.0	<3.0	2.0	<1.0
	Sep	<1.0	2.0	2.7	<2.0	6.0	2.0	<2.0	5.0	3.0
Strontium-89 (μμc/day)	Jul	10	55	<10	20	30	<5	190	15	45
	Aug	30	45	<10	40	15	15	105	30	40
	Sep	65	45	<10	25	5	10	35	20	60
Strontium-90 (μμc/day)	Jul	5	23	10	16	8	2	35	3	14
	Aug	6	30	11	12	8	9	31	17	19
	Sep	10	25	10	12	2	1	23	11	27
Cesium-137 (μμc/day)	Jul	<5	170	<10	20	60	50	50	210	55
	Aug	20	25	45	50	30	<10	100	90	100
	Sep	45	90	30	50	<5	100	80	50	50
Barium-140 (μμc/day)	Jul	30	90	<20	<20	40	<10	<30	<10	30
	Aug	40	70	<20	<20	40	<10	<30	<10	90
	Sep	<10	40	<20	<20	<10	<10	<20	<10	50
Iodine-131 (μμc/day)	Jul	40	50	<20	<20	60	<10	<30	<10	15
	Aug	40	<10	<20	<20	60	<10	<30	<10	50
	Sep	20	<10	<20	<20	<10	<10	<20	<10	65

[1] The row labeled "Phosphorus" in table 1, pages 472-3 of the December 1962 issue of *Radiological Health Data* is in error. This row should be labeled "Phosphorus as phosphate."

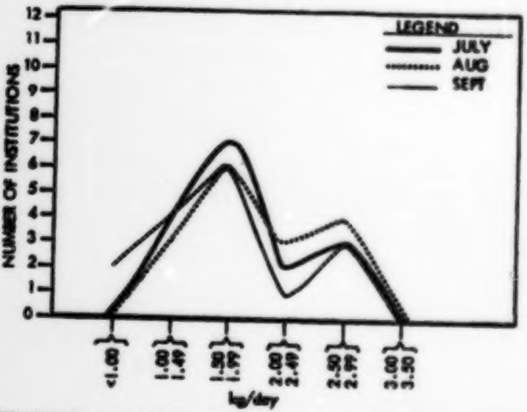

FIGURE 4.—DISTRIBUTIONS OF INSTITUTIONS VERSUS TOTAL DAILY DIETARY INTAKE ON A WEIGHT BASIS

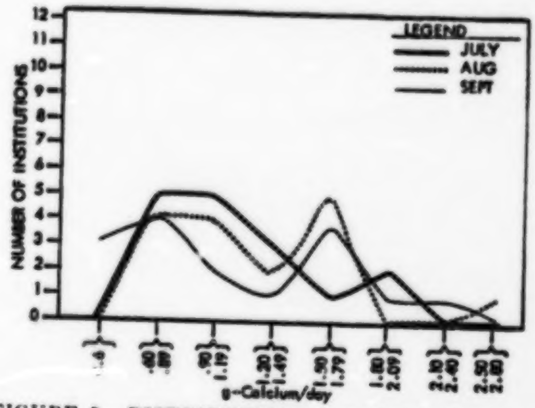

FIGURE 5.—DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY CALCIUM INTAKE

INTAKE (BASED ON A 7-DAY COMPOSITE SAMPLE)

Missouri, St. Louis	Montana, Helena	Nebraska, Omaha	New Mexico, Albuquerque	New York, New York	Ohio, Cleveland	Tennessee, Memphis	Texas, Austin	Utah, Salt Lake City	Virginia, Norfolk	Washington, Seattle	Monthly minimum average	Monthly maximum average
3.02 2.62	2.76 2.61 2.55	1.52 1.88	1.69 1.69 1.51	1.31	1.73 2.01 1.68	1.27 1.33 0.81	2.70 2.84 2.73	1.28	1.45 1.38 1.02	2.90 2.85 2.75	1.92 1.99 1.65	1.92 1.99 1.65
1.5 2.1	1.9 1.5 1.5	1.1 1.3	1.0 0.9 0.9	0.6	1.2 1.5 1.1	0.6 0.9 0.4	1.4 1.7 2.1	0.8	0.6 0.6 0.5	2.0 2.5 1.9	1.1 1.3 1.1	1.1 1.3 1.1
7.2 6.3	7.2 5.3 5.6	4.0 4.1	4.4 3.4 3.0	3.5	4.0 5.0 3.9	2.3 3.3 1.5	6.0 6.7 8.2	2.5	2.9 3.1 3.1	8.1 7.0 6.3	4.5 4.6 3.9	4.5 4.6 3.9
4.8 3.7	3.6 3.9 2.0	2.0 2.8	3.4 2.7 2.0	3.1	5.8 3.0 2.9	1.4 1.6 1.2	3.0 3.1 4.4	1.9	1.6 1.4 1.4	4.9 4.6 4.1	3.0 2.8 2.4	3.0 2.8 2.4
6.0 1.0	6.0 1.0 <1.0	3.0 4.0	<1.0 2.0 <1.0	<2.0	<1.0 2.0 2.0	1.6 3.7 <1.0	2.7 1.3 <3.0	<1.0	<2.0 1.5 <1.0	9.0 9.0 3.0	2.8 2.3 1.5	3.2 2.5 2.3
150 145	110 160 60	<10 70	3 10 10	<5	<5 15 5	<10 20 <5	20 <15 <15	30	135 15 15	100 50	46 45 26	49 46 28
42 34	17 34 22	14 18	10 4 4	6	7 6 9	16 16 6	17 20 26	9	11 9 12	35 25 25	15 17 14	15 17 14
120 90	95 100 50	25 75	15 25 30	40	225 40 30	15 25 10	40 55 55	70	20 40 35	160 215 110	74 63 56	75 63 56
150 100	190 100 50	50 20	80 <10 30	<10	<10 <10 10	<20 <20 <10	<30 <30 <30	40	<20 <20 <10	170 <10 <10	43 26 13	52 36 22
60 50	<10 100 <10	120 20	20 50 30	<10	<10 <10 10	<20 <20 <10	<30 30 <30	40	<20 <20 10	140 <10 <10	27 22 10	37 31 19

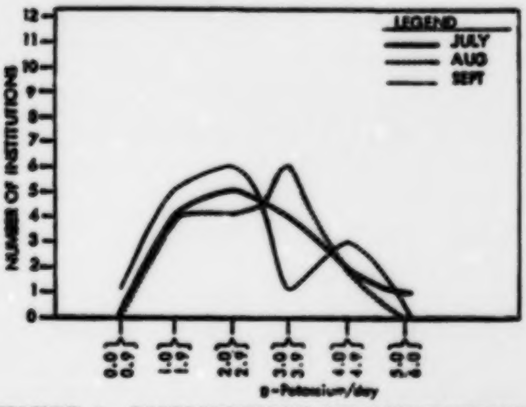

FIGURE 6.—DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY POTASSIUM INTAKE

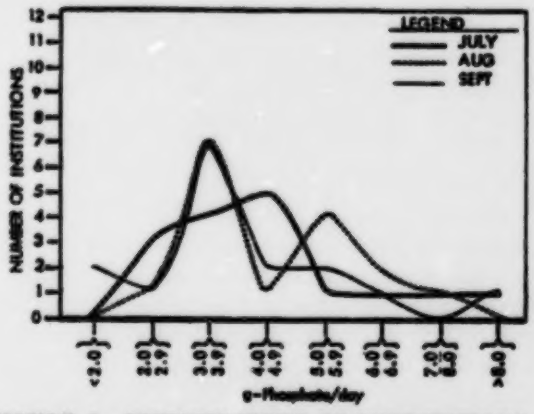

FIGURE 7.—DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY PHOSPHATE INTAKE

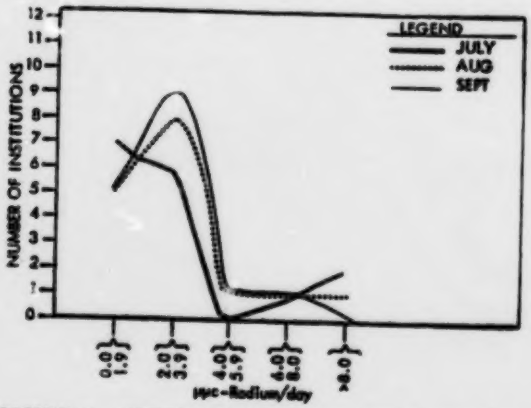

FIGURE 8.—DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY TOTAL RADIUM INTAKE

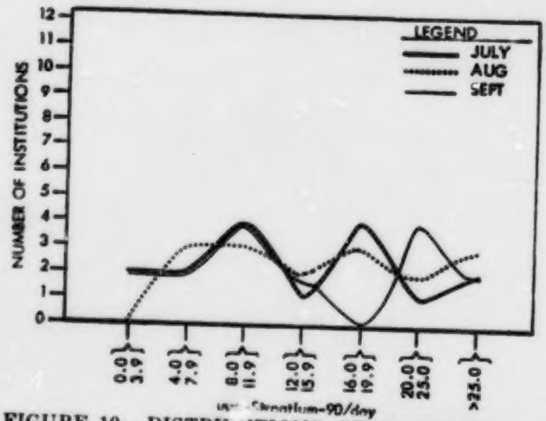

FIGURE 10.—DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY STRONTIUM-90 INTAKE

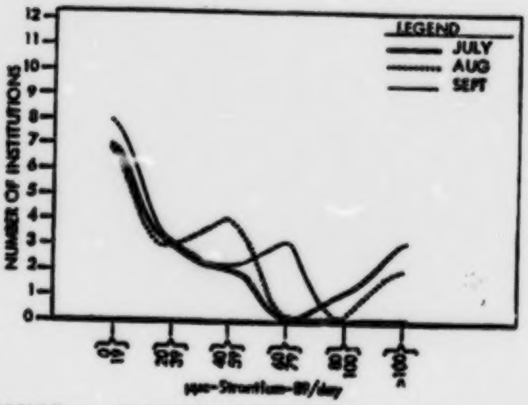

FIGURE 9.—DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY STRONTIUM-89 INTAKE

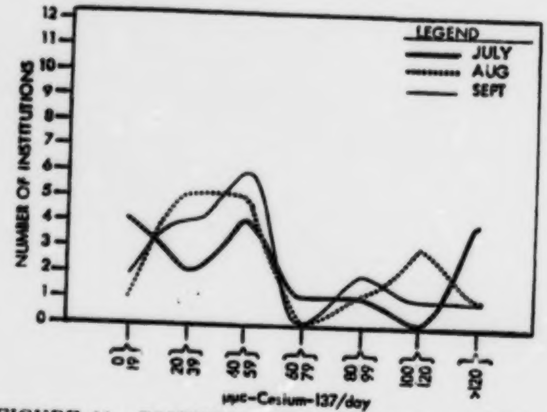

FIGURE 11.—DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY CESIUM-137 INTAKE

(figure 3) has normally ranged between 1.0 and 1.3 g/day while the calcium distribution (figure 5) usually has a well-defined peak. This quarter's results for calcium are not inconsistent with the above statements.

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(1) Anderson, E. C., and D. J. Nelson, Jr.: Surveillance for Radiological Contamination in Foods, *American Journal of Public Health*, *52*:1391-400 (September 1962).

(2) Chen, P. S., Jr., A. R. Terepka, and H. C. Hodge: The Pharmacology and Toxicology of the Bone Seekers, *Annual Review of Pharmacology*, *1*:369-96 (1961).

(3) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards*, Report No. 2, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (September 1961), price 20 cents.

(4) Chadwick, Donald R., and Conrad P. Straub: Considerations in Establishing Radiation Protection Standards for Radioactivity in the Environment, *Radiological Health Data*, *3*:159-65 (May 1962).

(5) Federal Radiation Council: *Health Implications of Fallout from Nuclear Weapons Testing Through 1961*, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (May 1962), price 15 cents.

SECTION III.—MILK

Milk Surveillance

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the U.S. population and contains most of the radionuclides identified as being biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

PASTEURIZED MILK NETWORK
December 1962

Division of Radiological Health and
Division of Environmental Engineering
and Food Protection,
Public Health Service

In 1957 the Public Health Service began analyzing raw milk to determine relationships between dairy practices and radionuclide levels in milk. However, it became evident that the milk actually consumed by the population should be included in a broader sampling program. In 1960 the pasteurized milk network was initiated to provide data representative of the milk consumed in selected municipalities. Both raw and pasteurized milk sampling data were reported concurrently until June 1961 to permit comparison of the differences between the earlier, limited, milkshed sampling results and those exhibited in pasteurized milk monitoring. Since June 1961, raw milk sampling has been carried out for investigative rather than monitoring purposes.

During December 1962, pasteurized milk surveillance was conducted at 62 Pasteurized Milk Network stations with the cooperation of State and local milk sanitation agencies which have been shipping samples to the PHS Southwestern, Southeastern, and Northeastern Radiological Health Laboratories for analysis. Publication in *Radiological Health Data* follows 3 to 4 months after sample collection because of the time required for shipment, processing, radioanalysis of strontium, data compilation, and publication procedures. Data from gamma analyses (iodine–131) are available to State public health officials and the Federal Radiation Council within 3 days after sample collection for possible countermeasure purposes.

Sampling and Compositing Procedures

The current program emphasizes (1) measurement of the concentrations of radioactivity in samples of pasteurized milk consumed by the public in various regions of the country, and (2) provision of at least one sampling point within virtually all States; additional points when indicated by widely varying conditions

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of the milk supply or when needed in order to cover large population groups. Each sample is a composite of subsamples which are specified to be collected from each plant in proportion to the relative volumes of milk sold. Each of the 62 stations reflects from 80 to 100 percent of the milk consumed in that city with the network average being about 90 percent. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was

TABLE 1.—RADIOACTIVITY IN PASTEURIZED MILK, DECEMBER 1962

[Average radioactivity concentrations in $\mu\mu c$/liter]

Sampling locations		Calcium (g/liter)		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
		Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month
Ala:	Montgomery	1.26	1.26	40	60	15	16	40	50	35	45	20	20
Alaska:	Palmer	1.33	1.33	80	40	13	11	110	30	60	60	30	20
Ariz:	Phoenix	1.32	1.30	25	20	5	4	20	20	20	20	<10	<10
Ark:	Little Rock	1.26	1.26	120	180	29	32	110	170	70	95	30	50
Calif:	Sacramento	1.32	1.31	20	20	4	4	20	20	20	20	10	10
	San Francisco	1.34	1.33	20	35	4	5	20	30	20	25	<10	<10
Colo:	Denver	1.34	1.38	20	15	11	11	20	<10	55	60	<10	<10
Conn:	Hartford	1.13	1.11	40	20	11	7	40	10	65	70	10	<10
Del:	Wilmington	1.11	1.11	50	30	15	15	80	40	70	75	20	10
D.C:	Washington	1.20	1.21	40	25	18	17	60	30	55	50	20	10
Fla:	Tampa	1.25	1.26	30	40	10	10	50	50	125	110	10	20
Ga:	Atlanta	1.24	1.25	55	85	17	17	60	90	55	65	20	20
Hawaii:	Honolulu	1.26	1.21	20	30	6	6	20	30	40	40	<10	10
Idaho:	Idaho Falls	1.31	1.30	25	15	13	14	40	20	75	80	10	20
Ill:	Chicago	1.12	1.10	45	30	12	9	70	20	65	70	10	<10
Ind:	Indianapolis	1.17	1.16	50	35	13	10	80	50	55	60	10	<10
Iowa:	Des Moines	1.36	1.33	75	55	14	14	110	80	50	55	20	20
Kans:	Wichita	1.34	1.32	55	45	13	15	70	80	40	45	20	20
Ky:	Louisville	1.23	1.24	95	100	23	20	80	60	45	55	40	40
La:	New Orleans	1.28	1.28	70	95	24	28	70	110	66	75	20	30
Maine:	Portland	1.15	1.18	50	15	17	16	50	10	110	100	20	<10
Md:	Baltimore	1.22	1.20	40	30	17	17	60	30	60	60	20	10
Mass:	Boston	1.13	1.09	60	15	19	17	50	10	110	100	20	<10
Mich:	Detroit	1.13	1.10	50	15	15	11	70	20	75	85	20	<10
	Grand Rapids	1.18	1.12	35	15	12	9	50	20	65	70	10	<10
Minn:	Minneapolis	1.32	1.29	70	25	23	23	70	20	95	95	30	30
Miss:	Jackson	1.30	1.32	90	155	19	24	70	100	45	55	30	40
Mo:	Kansas City	1.33	1.32	100	110	17	19	120	130	45	45	30	30
	St. Louis	1.35	1.33	55	45	14	14	60	30	45	50	20	30
Mont:	Helena	1.35	1.34	45	35	16	16	80	90	85	90	30	20
Nebr:	Omaha	1.37	1.45	60	50	15	16	90	120	55	60	20	10
Nev:	Las Vegas	1.26	1.18	25	25	6	5	10	<10	40	40	<10	<10
N.H:	Manchester	1.16	1.11	50	15	18	15	40	10	115	115	10	<10
N.J:	Trenton	1.12	1.10	45	25	13	8	60	20	65	65	20	<10
N. Mex:	Albuquerque	1.33	1.32	20	30	5	6	30	40	25	25	20	10
N.Y:	Buffalo	1.10	1.11	40	15	13	10	40	10	80	85	10	<10
	New York	1.13	1.13	55	20	17	11	80	20	75	65	20	<10
	Syracuse	1.14	1.12	45	20	14	11	50	10	65	65	10	<10
N.C:	Charlotte	1.27	1.27	50	45	19	21	20	20	50	50	20	20
N.D:	Minot	1.34	1.32	60	25	27	33	60	10	75	85	20	20
Ohio:	Cincinnati	1.15	1.16	60	50	17	14	90	60	45	55	10	10
	Cleveland	1.16	1.15	50	25	14	12	70	40	60	70	<10	<10
Okla:	Oklahoma City	1.21	1.22	65	90	17	19	100	160	40	50	20	30
Ore:	Portland	1.40	1.38	150	145	18	18	60	50	80	80	40	30
Pa:	Philadelphia	1.13	1.11	45	30	14	11	80	30	60	70	10	<10
	Pittsburgh	1.14	1.12	55	40	19	14	110	50	80	85	20	10
P.R:	San Juan	1.17	1.18	75	130	10	13	30	60	45	60	10	20
R.I:	Providence	1.11	1.12	45	15	16	11	60	20	85	85	20	<10
S.C:	Charleston	1.26	1.28	50	80	20	23	40	70	60	65	20	20
S.D:	Rapid City	1.17	1.25	50	35	15	20	70	40	70	85	20	20
Tenn:	Chattanooga	1.28	1.30	95	135	20	24	60	70	50	60	30	50
	Memphis	1.25	1.25	85	110	20	20	80	100	40	45	30	40
Tex:	Austin	1.23	1.25	35	75	8	10	90	200	30	50	20	40
	Dallas	1.23	1.25	90	195	16	19	150	330	45	75	30	60
Utah:	Salt Lake City	1.35	1.33	30	25	11	10	40	20	75	70	30	30
Vt:	Burlington	1.11	1.10	55	20	13	10	60	<10	85	85	20	<10
Va:	Norfolk	1.23	1.23	45	40	20	20	50	40	60	60	20	20
Wash:	Seattle	1.36	1.33	100	55	21	14	60	30	85	75	40	20
	Spokane	1.40	1.38	35	25	15	17	30	20	80	85	10	10
W. Va:	Charleston	1.22	1.21	60	35	21	19	40	20	55	55	20	20
Wis:	Milwaukee	1.18	1.16	45	20	11	8	90	20	70	75	20	<10
Wyo:	Laramie	1.32	1.29	45	40	12	12	20	<10	80	95	10	10
Network average		1.24	1.23	55	50	15.1	14.6	61	51	62	66	19	17

as representative of a community's total supply as could be achieved under practical conditions. Since the resumption of nuclear weapons testing, the sampling frequency has been increased. During December 1962, most stations were sampled twice a week. All surveillance data are subject to continuing review and evaluation to observe unusual patterns or concentrations which may require immediate attention. Further atmospheric nuclear testing may require re-evaluation and adjustment of the sampling frequency and analytical schedule for this program.

Iodine–131, cesium–137, and barium–140 are determined by gamma scintillation spectroscopy,[1] while strontium–89 and strontium–90 are determined by radiochemical procedures. The minimum detectable concentrations in units of μμc/liter are: Sr^{89}, 5; Sr^{90}, 1; I^{131}, 10; Cs^{137}, 5; and Ba^{140}, 10.

Table 1 presents summaries of all available analyses for December 1962. When a radionuclide is reported by a laboratory as being below the minimum detectable concentration, one-half of this value is used in calculating the monthly average. A similar procedure is used for the network average.

Geographical Variation in Radionuclide Content of Milk (1962)

Iodine–131: Beginning in January 1962 and continuing through February, March, and April, the monthly average iodine–131 concentrations in milk were very low (20 μμc/liter or less) over the entire country. The lowest monthly average values occurred in April. Except in the Southwest, iodine–131 was nondetectable. In May there was a pronounced increase of iodine–131 in milk in Kansas and Missouri. Monthly averages there slightly exceeded the 200 μμc/liter level. Concentrations decreased with distance from the Kansas-Missouri area and dropped to values of 20 μμc/liter or less at the Rocky Mountains, the Appalachian Mountains, the northern part of Texas, and the U.S.–Canadian border. This same focal point was evident in June with approximately the same levels as before noted for milk. Also, a concentration of 350 μμc/liter was observed in eastern Washington in June.

Values for iodine–131 in the Kansas-Missouri area and eastern Washington decreased to below 80 μμc/liter in July. There was however, an iodine–131 concentration of almost 600 μμc/liter noted in Utah in July. August concentrations in milk were below those in July and most of the network stations reported values below 50 μμc/liter. High concentrations in Utah persisted, although the levels decreased to about 300 μμc/liter. September and October concentration contour maps were generally similar. The reported values for the southwestern states were below 20 μμc/liter while various northern States reported concentrations somewhat greater than 100 μμc/liter. In November, a region of iodine–131 concentrations ranging from 100 to 170 μμc/liter extended from Pennsylvania to Oklahoma and from Oklahoma to Wisconsin. Of note in December were average values which reached 300 μμc/liter or slightly greater in eastern Texas (see figure 1). The South and Midwest, as well as an area including Washington, Oregon, Idaho, and Montana, had concentrations of iodine–131 in milk of at least 50 μμc/liter.

In summary, iodine–131 did not appear appreciably in milk until May, and its presence continued throughout the balance of the calendar year. The Southwest usually had low iodine–131 concentrations in milk, however no portion of the country was consistently high. Occasionally, high monthly average concentrations of iodine–131 appeared in various locations.

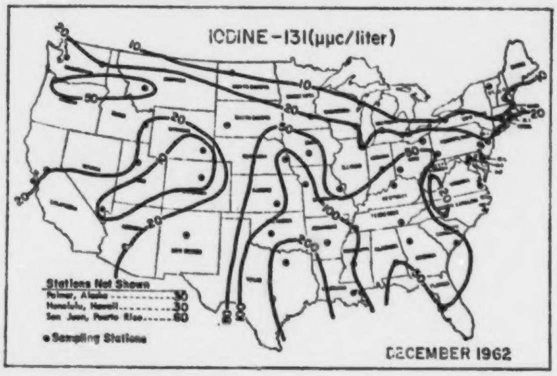

FIGURE 1.—IODINE–131 CONCENTRATIONS IN PASTEURIZED MILK

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.

Strontium–89: Stontium–89 monthly average concentrations in milk for January 1962 reached levels of about 300 μμc/liter in Louisiana, but levels decreased rapidly with distance from this area. For the same month, only the Southeast reported concentrations greater than 50 μμc/liter. February and March concentration contour maps appeared remarkably similar in form and level. The epicenter for the 300 μμc/liter concentration for strontium–89 appeared to move northward to the Arkansas-Mississippi-Alabama area in April. The 100 μμc/liter concentration contour centered about this area appeared to expand up the Mississippi Valley during May. Western Washington-Oregon also experienced concentrations of about 100 μμc/liter in May. Concentrations in this area decreased during May. The northern expansion of the 100 μμc/liter contour continued until June when a ridge of strontium–89 concentration of 100 μμc/liter extended from North Dakota to Louisiana. Only the northern portion of this ridge persisted in July. In August, only Wyoming, Nebraska, and Oregon had concentrations somewhat in excess of 100 μμc/liter while in September all of the coterminous U.S. stations reported values lower than 100 μμc/liter. A strontium–89 intrusion of about 100 μμc/liter occurred in the Minnesota-Iowa area and in the Washington-Oregon area in October. During November concentrations of strontium–89 of 100 to 200 μμc/liter appeared in Washington-Oregon, Arkansas, and Kentucky-Tennessee. Strontium–89 in milk in these same areas continued in December. However, two of the highs had merged to form one with concentrations of 100 to 200 μμc/liter covering eastern Texas and the lower Mississippi Valley (see figure 2).

Strontium–90: The monthly average strontium–90 concentrations in milk for January 1962 were generally below 10 μμc/liter. The South and the East had values greater than 10 μμc/liter and the Arkansas-Mississippi-Louisiana area reported values of 20 to 24 μμc/liter. This area of high concentrations continued during February and expanded to include northern Alabama in March. In April, the southeastern States reflected a 20 to 30 μμc/liter concentration pattern for strontium–90. The lower Mississippi Valley reported concentrations up to 40 μμc/liter during this period. Approximately these same conditions existed throughout May and June. An average of 40 μμc/liter appeared in South Dakota in June. The effect of this intrusion was to extend the greater-than-20 μμc/liter concentration area all the length of the Mississippi Valley. In July much the same conditions prevailed as in June. During August, strontium–90 concentrations appeared to decline. Only the Dakotas, the lower Mississippi Valley, and the southern Appalachian States reported values of 20 to 27 μμc/liter. In September, the Dakotas' high had disappeared. October averages of 20 to 29 μμc/liter occurred in the lower Mississippi Valley, along the eastern seaboard, and in the Northwest. Conditions for November were similar to October, except that the high along the eastern seaboard had decreased. The December

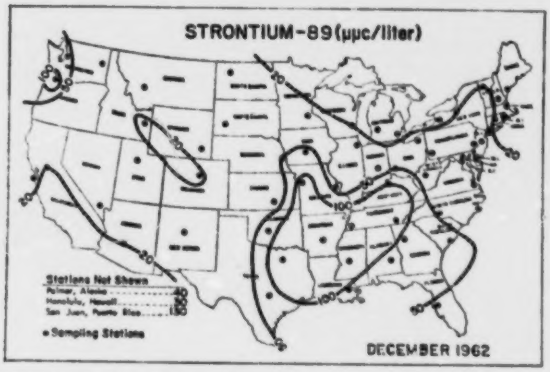

FIGURE 2.—STRONTIUM–89 CONCENTRATIONS IN PASTEURIZED MILK

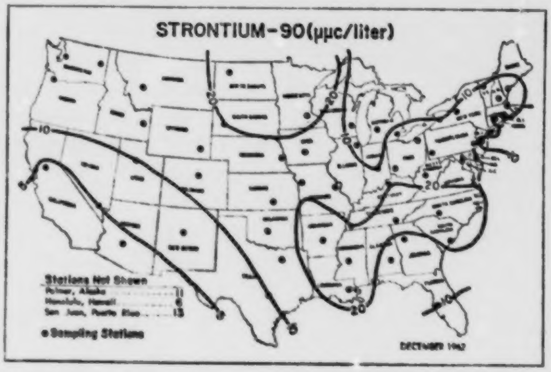

FIGURE 3.—STRONTIUM–90 CONCENTRATIONS IN PASTEURIZED MILK

monthly averages of strontium-90 concentrations in milk are presented in figure 3. Monthly averages of 20 to 33 μμc/liter were reported for Minnesota, the Dakotas, and most of the Southern States.

In summary, most of the stations reported values of strontium-90 in milk of between 10 and 20 μμc/liter throughout the entire year. The Southwest was consistently low (< 10 μμc/liter) while the lower Mississippi Valley consistently displayed higher values (20 to 40 μμc/liter). The Southeastern and the Great Plains States sporadically showed values of 20 to 40 μμc/liter.

Selected Monthly Strontium-90 Profiles

In previous issues of *RHD*, the average monthly strontium-90 concentrations in pasteurized milk from selected cities in the monitoring program were published. Profiles for an additional 16 cities are presented in figure 4. These graphs show the strontium-90 concentrations in milk from selected cities in the 4 major Bureau of the Census regions.

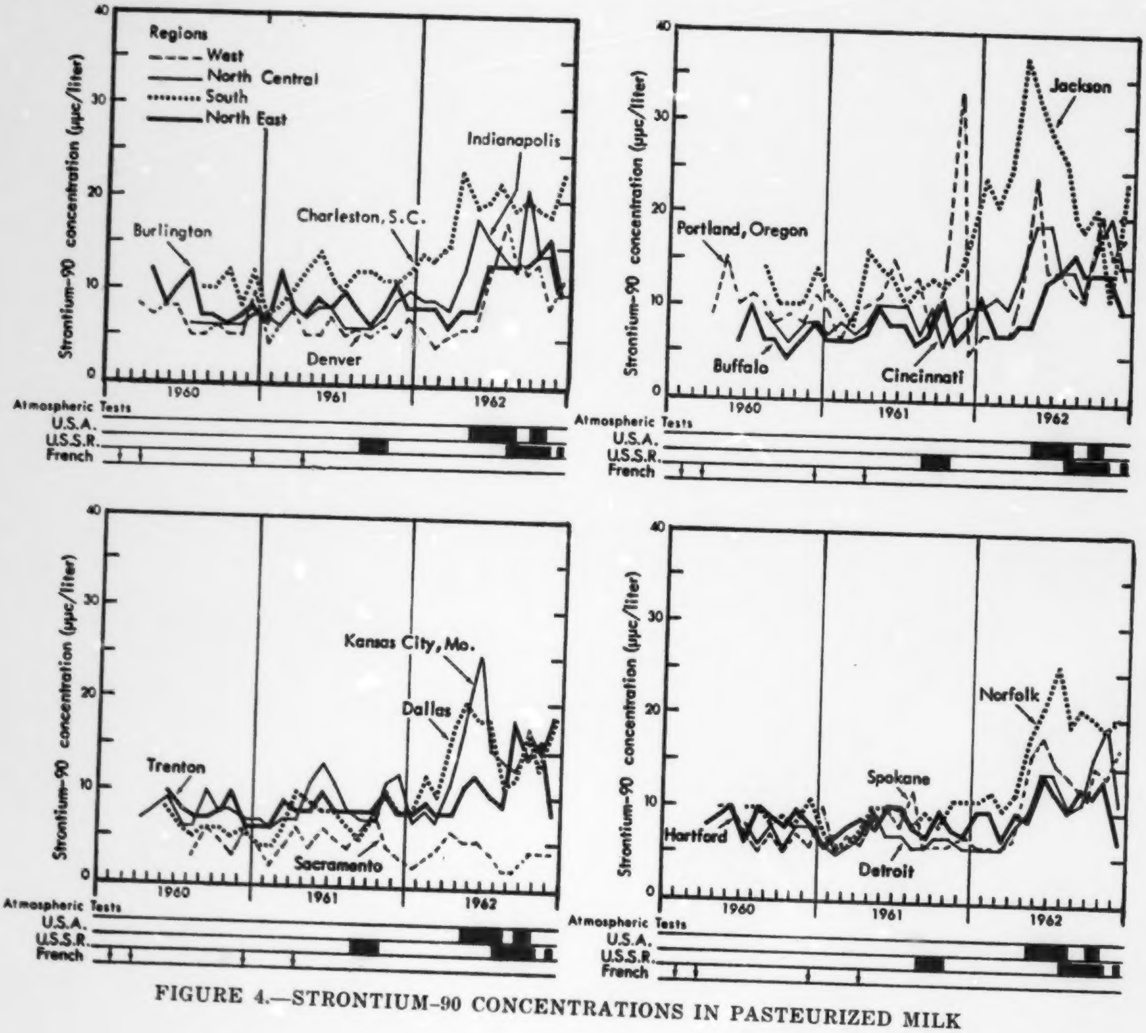

FIGURE 4.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

INDIANA MILK NETWORK
December 1962–January 1963

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analyses in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (see figure 5).

The milk samples are routinely analyzed for iodine–131, cesium–137, barium-lanthanum–140, strontium–89, and strontium–90. Analyses for the gamma emitters iodine–131, cesium–137, and barium-lanthanum–140 are conducted on a weekly basis except when iodine–131 results exceed 100 μμc/liter, at which time the frequency of sampling is increased. Strontium–89 and strontium–90 analyses are performed monthly on samples which are composited from weekly aliquots.

The ion exchange analytical procedure (*1*) is used for strontium–89 and strontium–90 analyses. A 512-channel pulse-height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine–131, cesium–137, and barium-lanthanum–140.

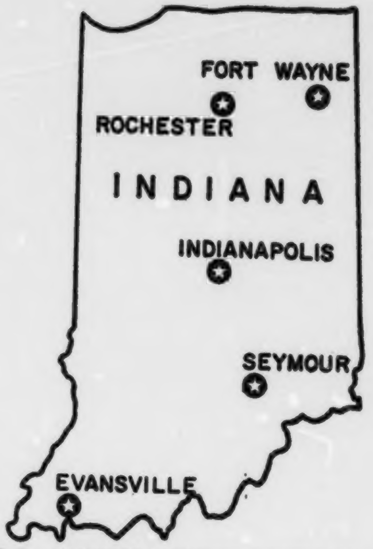

FIGURE 5.—INDIANA MILK SAMPLING LOCATIONS

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 2. The State average is an arithmetic average of the station values.

REFERENCE

(*1*) Porter, C., D. Cahill, R. Schneider, P. Robbins, W. Perry, and B. Kahn: Determination of Strontium–90 in Milk by an Ion Exchange Method, *Analytical Chemistry* *33*:1306–8 (September 1961).

TABLE 2.—RADIONUCLIDES IN INDIANA MILK, DECEMBER 1962–JANUARY 1963

[Concentrations in μμc/liter]

Sampling location	Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-Lanthanum-140	
	December	January	December	January	December	January	December	January	December	January
Evansville	20	20	22	17	20	<10	45	50	<10	<10
Fort Wayne	30	—	16	18	10	<10	45	50	<10	<10
Indianapolis	50	<10	22	23	30	<10	50	55	<10	<10
Rochester	15	<10	18	22	20	<10	50	55	<10	<10
Seymour	20	<10	20	24	30	<10	50	50	10	<10
State average	25	10	20	21	20	<10	50	50	<10	<10

MINNESOTA MILK NETWORK
March–September 1962

Division of Environmental Sanitation
Minnesota Department of Health

The Minnesota State Department of Health initiated a pasteurized milk surveillance network in September 1958 to monitor milk for strontium-90. Since then the network has been expanded to eleven sampling locations (see figure 6). In October 1961 a special network of eight stations (see figure 6) was established for the collection of milk "grab" samples for iodine-131 analyses.

Each station daily collects a two-ounce sample and produces a monthly composite sample to be analyzed for strontium-90. Collection is made at the pasteurizing plants' bottling machines so that the sample is randomly representative of the milk produced in that milkshed. The most recent strontium-90 data is shown in table 3.

One-liter samples are collected weekly for iodine-131 analyses. These monthly averages are shown in table 4. The minimum detectable concentration of iodine-131 in milk is 15 μμc/liter. The monthly average is an arithmetic average of all samples collected within a given month. A value of 7 μμc/liter is used when averaging values which are reported as < 15 μμc/liter. If the calculated monthly average is below 15 μμc/liter, then the monthly average is reported as < 15 μμc/liter. All other monthly averages have been rounded to the nearest 10 μμc/liter.

Analytical Procedure

Strontium-90 in milk is determined by ashing an 800 ml sample, after evaporation at 450° C. Calcium and strontium are precipitated as oxalates from the ash. The separated oxalates are destroyed and the resulting solution scavenged with yttrium and barium. Yttrium-90 is allowed to ingrow and is then precipitated. This precipitate is converted to the oxalate, filtered and counted in a low-background anticoincidence counter.

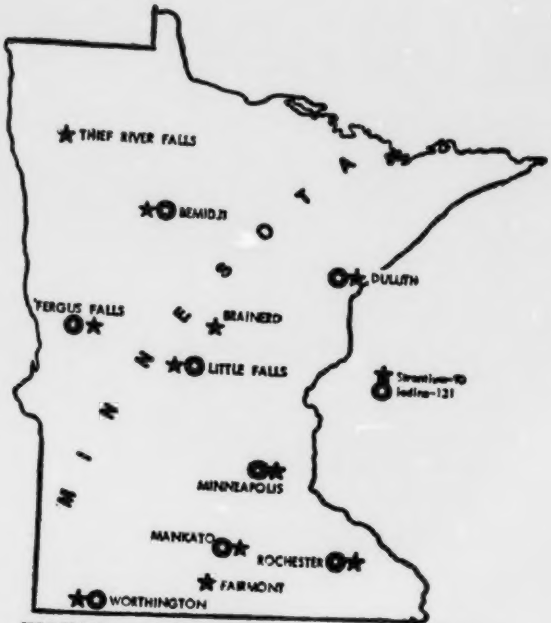

FIGURE 6.—MINNESOTA MILK SAMPLING LOCATIONS

Iodine-131 is determined by gamma spectrometry. One-liter samples of milk are counted for 100 minutes with a low-background sodium iodide crystal scintillator and multichannel analyzer. The counts in the iodine-131 photopeak (0.36 Mev) which occur because of background and scatter from other gamma-emitting nuclides in milk are determined empirically and subtracted from the total count.

TABLE 3.—STRONTIUM-90 IN MINNESOTA MILK, MARCH-SEPTEMBER 1962

[Concentrations in μμc/liter]

Sampling location	March	April	May	June	July	August	September
Bemidji	—[a]	—	16.7	34.0	34.6	36.9	21.8
Brainerd	9.6	9.1	—	—	—	—	—
Duluth	—	7.7	14.8	38.0	35.4	15.4	26.9
Fairmont	2.5	4.1	—	—	—	—	—
Fergus Falls	—	—	18.1	26.0	25.5	21.8	21.9
Little Falls	—	—	33.0	27.0	38.0	29.9	26.4
Mankato	—	—	6.3	16.0	11.8	29.2	12.2
Minneapolis	4.3	4.2	10.9	20.0	21.8	21.1	17.7
Rochester	—	5.6	9.7	14.0	18.7	12.0	12.7
Thief River Falls	3.2	4.0	—	—	—	—	—
Worthington	—	—	8.8	—	20.1	15.0	16.4

[a] A dash indicates no sample.

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TABLE 4.—AVERAGE IODINE-131 IN MINNESOTA MILK, MARCH–AUGUST 1962

[Concentrations in μμc/liter]

Sampling location	March	April	May	June	July	August
Bemidji	[a]—	—	50	20	40	30
Duluth	<15	<15	30	20	20	30
Fergus Falls	—	—	110	20	50	20
Little Falls	—	—	60	40	40	40
Mankato	—	—	60	40	40	30
Minneapolis	—	—	70	40	20	20
Rochester	—	—	60	30	<15	50
Worthington	<15	<15	250	70	40	30

[a] A dash indicates no sample.

Recent coverage in *Radiological Health Data*:

Period	Issue
October–December 1961 (iodine-131 data)	*March 1962*
May–December 1961 (strontium-90 data)	*August 1962*

NEW YORK MILK NETWORK
October–November 1962

Division of Special Health Services
State of New York Department of Health

Pasteurized milk samples, collected routinely from six cities—Albany, Buffalo, Massena, Newburgh, New York City, and Syracuse (figure 7), are analyzed for radionuclide content by the State of New York Department of Health. Weekly composites of daily samples are analyzed for strontium-89, strontium-90 and iodine-131. The milk samples are collected daily from processing plants in all cities except Albany, where collection is made at a market.

At Albany and New York City daily iodine-131 analyses have been made. In the event that a city reports iodine-131 concentrations exceeding 100 pc/liter, increased surveillance is undertaken. The matrix method (*1*) is used for the analysis of spectral data to determine the concentrations of gamma-emitting nuclides in milk. With this method, the individual nuclide contributions to the gamma spectrum were separated by solution of simultaneous equations describing the spectral interferences.

The analytical procedure for strontium-89 and strontium-90 is based on ion exchange methods to concentrate the strontium, elution

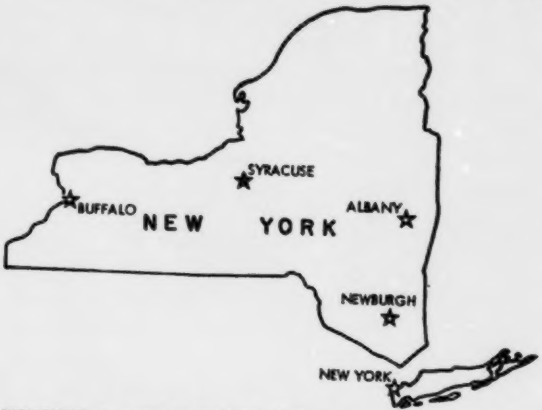


FIGURE 7.—NEW YORK MILK SAMPLING LOCATIONS

TABLE 5.—RADIONUCLIDES IN NEW YORK MILK, OCTOBER–NOVEMBER 1962

[Concentrations in pc/liter]

Sampling location	Strontium-89		Strontium-90		Iodine-131		Cesium-137	
	Oct.	Nov.	Oct.	Nov.	Oct.	Nov.	Oct.	Nov.
Albany	50	30	11	11	40	25	55	65
	[a](4)	(4)	(4)	(4)	(26)	(25)	(22)	(25)
Buffalo	42	30	9	11	45	<20	50	62
	(6)	(4)	(6)	(4)	(5)	(6)	(5)	(6)
Massena	100	35	20	12	65	<20	90	117
	(4)	(4)	(4)	(4)	(7)	(4)	(8)	(4)
Newburgh	100	51	7	10	45	43	55	77
	(3)	(4)	(3)	(4)	(7)	(3)	(7)	(5)
New York City	80	46	19	9	75	55	[b]—	—
	(3)	(5)	(3)	(5)	(17)	(14)		
Syracuse	45	21	11	7	65	<20	31	44
	(3)	(3)	(3)	(3)	(6)	(3)	(5)	(5)

[a] Numbers in parentheses indicate the number of samples upon which the monthly average is based.
[b] A dash indicates no sample.

of strontium isotopes from the ion exchange resin with sodium chloride, gathering by means of sodium carbonate, isolation by means of ethylenediaminetetraacetic acid, (EDTA) and counting of radiostrontium with a low-background beta counter having a 0.8 mg/cm^2 window. The strontium–90 is differentially estimated by a second count 40 hours later to determine the rate of growth of its daughter product, yttrium–90.

Table 5 shows the monthly radionuclide concentration averages for October and November 1962. The numbers in parentheses below the data values are the number of determinations used to compute the monthly average.

REFERENCE

(*1*) Hagee, G. R. et al.: Determination of Iodine–131, Cesium–137, and Barium–140 in Fluid Milk By Gamma Spectroscopy, *Talanta 5*:36 (1960).

RADIOSTRONTIUM IN MILK (*1*)

July–September 1962

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Health and Safety Laboratory (HASL) began monitoring liquid whole milk in New York City in 1954 for strontium–90 in order to estimate the dietary contribution from the ingestion of radiostrontium in milk. Subsequently, powdered milk monitoring was initiated at Perry, New York, and at Mandan, North Dakota. Liquid whole milk monitoring was started in Honolulu, Hawaii in August 1959.

The New York City sample is a monthly composite of pasteurized milk purchased daily in quart containers at retail stores. Five large dairies are represented in the sample. The Honolulu sample is a monthly composite of pasteurized milk collected weekly. Samples from two dairies are analyzed and the results are averaged. The Mandan and Perry samples are monthly composites of powdered milk collected in 5-pound lots from plants in each city. The Mandan sample is powdered buttermilk used for cattle feed, while the Perry sample is powdered whole milk used for human consumption. The Honolulu data are of interest since the cows there are on pasture throughout the year and soil analyses have shown strontium–90 concentrations in soils in Hawaii to be comparable with those in the New York area (*2*).

Strontium–89 became measurable in September 1961, indicating that fresh fission products from the U.S.S.R. nuclear test series were being deposited. The Sr^{89}/Sr^{90} ratios are presented in tables 6 and 7, as are the calcium and strontium data. The fluctuations of strontium–90 with time are shown in figures 8 and 9.

Comment

The Honolulu milk samples still contain less strontium–90 per liter than those of other sampling stations. The 1961 average showed a downward trend in μμc Sr^{90}/g Ca at each station. However, since the first quarter 1962 levels have risen at all stations and, during the spring and summer of 1962, reached levels comparable to those observed in 1959.

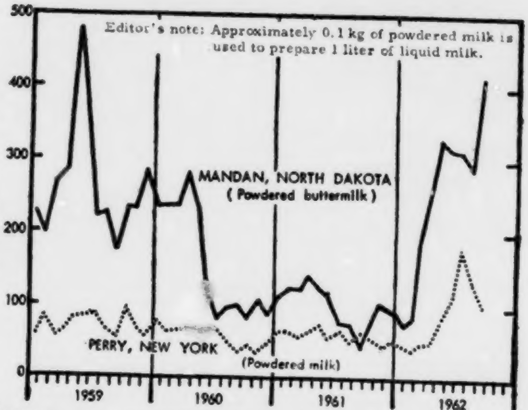


FIGURE 8.—STRONTIUM–90 IN POWDERED MILK SAMPLES

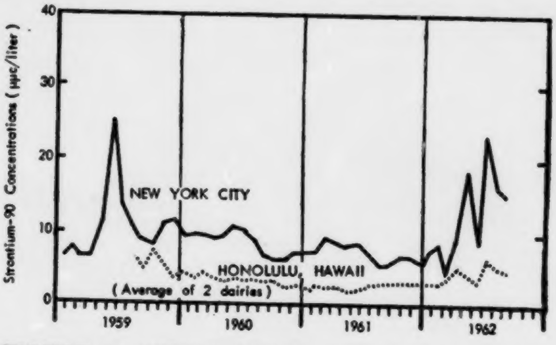


FIGURE 9.—STRONTIUM–90 IN LIQUID MILK SAMPLES

TABLE 6.—RADIOSTRONTIUM AND CALCIUM IN LIQUID MILK, FIRST THREE QUARTERS, 1962

Sampling station and period	Calcium (g/liter)	Strontium-90 (μμc/liter)	Strontium-90 (μμc/g Ca)	Sr^{89}/Sr^{90}*
New York City				
1959 Average			11	
1960 Average			8.0	
1961 Average			6.7	
1962 First quarter			5.3	
Second quarter			10.9	
July	1.02	23.7	23.3	4
August	0.93	16.2	17.4	3
September	0.99	15.1	15.3	6
Honolulu, Hawaii				
1959 Average			5.0	
1960 Average			3.2	
1961 Average			2.4	
1962 First quarter			2.8	
Second quarter			4.1	
July	1.05	6.3	6.0	3
August	1.13	5.4	4.8	3
September	1.11	4.7	4.3	2

* Strontium-89 value extrapolated to the midpoint of sampling period.

TABLE 7.—RADIOSTRONTIUM AND CALCIUM IN POWDERED MILK AND BUTTERMILK, FIRST THREE QUARTERS, 1962

Sampling station and period	Calcium (g/kg)	Strontium-90 (μμc/kg)	Strontium-90 (μμc/g Ca)	Sr^{89}/Sr^{90}*
Powdered milk				
Perry, New York				
1959 Average			8.0	
1960 Average			6.5	
1961 Average			6.2	
1962 First quarter			5.3	
Second quarter			9.1	
July	8.4	182	21.7	3
August	8.7	136	15.6	3
September	7.5	106	14.2	2
Powdered buttermilk				
Mandan, North Dakota				
1959 Average			25.7	
1960 Average			15.0	
1961 Average			9.4	
1962 First quarter			10.5	
Second quarter			26.0	
July	9.3	312	33.6	4
August	10.8	289	26.8	5
September	11.7	420	35.9	5

* Strontium-89 value extrapolated to the midpoint of sampling period.

Previous coverage in *Radiological Health Data*:

Period	Issue
December 1960–April 1961	*December 1961*
May–July 1961	*March 1962*
August–December 1961	*June 1962*
January–February 1962	*September 1962*
March–June 1962	*January 1963*

REFERENCES

(1) U.S. Atomic Energy Commission: *Fallout Program Quarterly Summary Report, HASL-132*, Office of Technical Services, Department of Commerce, Washington 25, D.C. (January 1, 1963), price $3.50.

(2) U.S. Atomic Energy Commission: *Summary of Available Data on the Strontium-90 Content of Foods and of Total Diets in the United States, HASL-90*:4, Office of Technical Services, Department of Commerce, Washington 25, D.C. (August 18, 1960).

CANADIAN MILK NETWORK
November 1962

Radiation Protection Division
Department of National Health and Welfare,
Ottawa, Canada

Dried Milk Products

Beginning in November 1955, radiochemical analyses of skim milk and buttermilk powders for strontium–90 concentrations were initiated by the Department of National Health and Welfare. Since April 1962, analyses for strontium–89 and cesium–137 have also been included.

Samples are collected through the cooperation of the Dairy Products Division of the Canadian Department of Agriculture, whose inspectors pick up four 1-pound samples of dried milk from each station (see figure 10) on a monthly schedule.

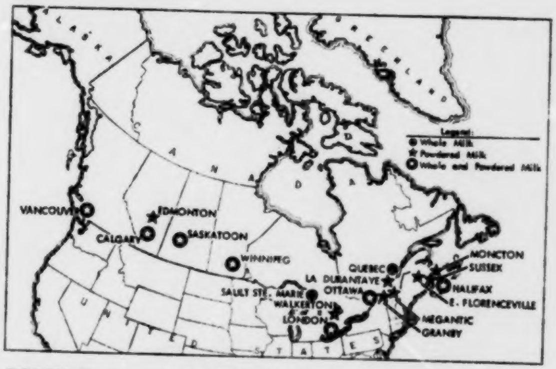
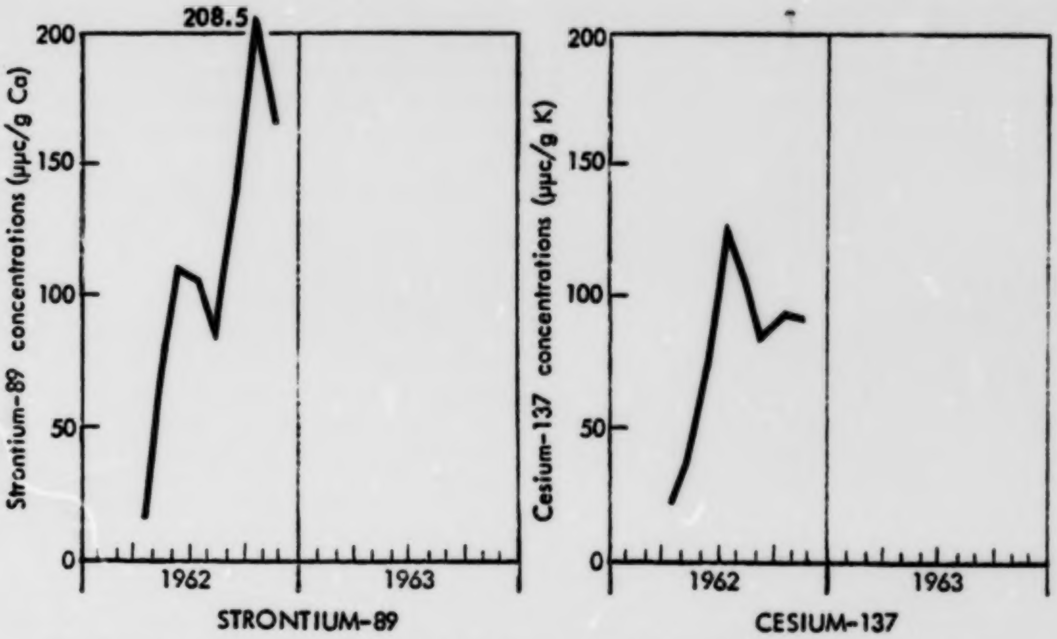


FIGURE 10.—CANADIAN MILK SAMPLING STATIONS

No statistical plan is followed for sample collection. Because of uncertainties introduced by this method of sampling, the significance of differences between station-to-station and month-to-month results is not precisely known. However, it is possible to consider all results for a given period of time as being sufficiently random in selection to show any national trend when average values for such periods and all stations are plotted, as in figures 11 and 12.

A detailed discussion of the sampling and radiochemical procedures employed may be found in the Department's publications (*1, 2*). Table 8 presents the results of measurements



STRONTIUM-89 CESIUM-137

FIGURE 11.—AVERAGE CONCENTRATIONS IN CANADIAN DRIED MILK POWDER

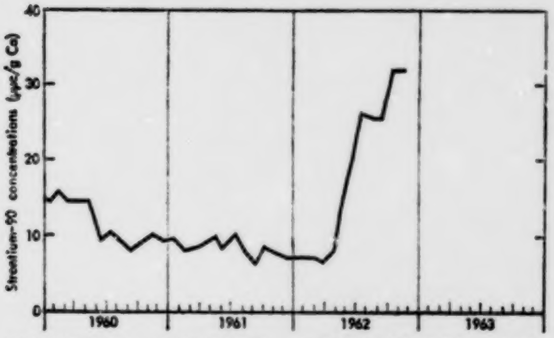


FIGURE 12.—AVERAGE STRONTIUM-90 CONCENTRATIONS IN CANADIAN DRIED MILK POWDER

of strontium-89, strontium-90, and cesium-137 in Canadian dried milk powder for November 1962. These data were taken from the "Data from Radiation Protection Programs," dated January 1963, published by the Radiation Protection Division of the Department of National Health and Welfare.

For an approximate method to compare the Canadian powdered milk data in units of μμc/g calcium to other milk data in units of μμc/liter, it can be assumed that milk has approximately 1.2 g calcium/liter of liquid milk. Canadian powdered milk data may be compared to liquid milk data by multiplying the former values by 1.2.

TABLE 8.—RADIONUCLIDES IN CANADIAN DRIED MILK POWDER, NOVEMBER 1962

Station	Strontium-89 (μμc/g Ca)	Strontium-90 (μμc/g Ca)	Cesium-137 (μμc/g K)
Arborg	85.5	24.6	86
Calgary	197.2	39.9	94
E. Florenceville	[a]—	—	—
Edmonton	124.4	30.1	87
Grunthal	64.5	23.8	69
Halifax	192.6	50.3	133
La Durantaye	43.2	30.8	98
Lawrenceville	209.9	34.3	131
London	136.2	18.1	66
Megantic	—	—	—
Moncton	156.8	47.3	124
Nicolet	187.6	25.1	70
Ottawa	150.8	19.2	67
Saskatoon	132.8	29.4	33
Sussex	282.5	63.6	124
Vancouver	392.5	38.8	118
Walkerton	91.0	15.7	55
Average	163.2	32.7	90.3

[a] Dash indicates no sample.

Whole Milk

Recently, monitoring of liquid whole milk for iodine-131 was begun. Table 9 presents the November and December average concentration of iodine-131 in liquid whole milk for nine cities. It may be noted that the average, which

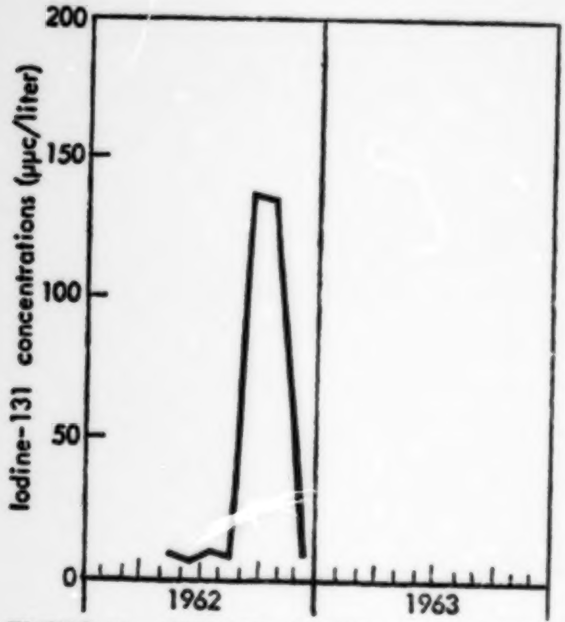


FIGURE 13.—AVERAGE IODINE-131 CONCENTRATIONS IN CANADIAN WHOLE MILK

TABLE 9.—IODINE-131 IN CANADIAN LIQUID WHOLE MILK, 1962

[Concentrations in μμc/liter]

Station	November	December
Calgary	114 (13)*	9 (12)
Halifax	38 (13)	10 (10)
London	51 (13)	—
Ottawa	15 (12)	5 (10)
Quebec	31 (13)	7 (11)
Saskatoon	84 (13)	4 (10)
Sault Ste. Marie	24 (12)	8 (11)
Vancouver	86 (12)	8 (10)
Windsor	—	12 (7)
Winnipeg	14 (13)	3 (12)
Average	51	7

* Numbers in parentheses indicate the number of samples on which the monthly average is based.

increased to about 135 μμc/liter during September and October, has decreased to 51 μμc/liter for November (see figure 13). In December the average further fell to 7 μμc/liter, indicating very little fresh fallout entering the milk.

It should be emphasized again that the interpretation of fallout data in relation to health is a complex problem. In comparing the values of the concentration levels in a particular medium with the so-called Maximum Permissible Concentrations (MPC's) as established by the International Commission on Radiological Protection (*3*), it is necessary to keep in mind that the MPC values refer to conditions of continuous exposure over a lifetime. Therefore, the average levels over an extended period, such as one year, represent a better basis for comparison than do individual levels at any specific time.

Previous coverage in *Radiological Health Data*:

Period	Issue
Third quarter 1961	*May 1962*
Fourth quarter 1961	*September 1962*
First quarter 1962	*October 1962*
Second quarter 1962	*January 1963*
Third quarter 1962	*February 1963*
October 1962	*March 1963*

REFERENCES

(*1*) Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada: *The Preliminary Report on the Measurements of Radioactive Strontium in Canadian Milk Powder Samples, CNHW (RPD-1)* (July 1958).

(*2*) Mar, Peter G.: *Outline of Procedure for the Radiochemical Analysis of Dried Milk Powders for Strontium and Yttrium, RPD-5,* Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada (June 1, 1960).

(*3*) Recommendations of the International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation,* Pergamon Press, New York (1959).

36

MEXICAN MILK NETWORK

March–October 1962

Radiological Protection Program

National Commission of Nuclear Energy,

Mexico

The Pasteurized Milk Monitoring Program of Mexico was established by the "Comision Nacional de Energía Nuclear" through its Radiological Protection Program in March 1962 to provide a means for estimating the ingestion of strontium-90 from milk.

Milk has been analyzed from twelve cities distributed throughout Mexico (see figure 14). Since each city is supplied from a large number of sources, it has not been possible, until now, to apply a representative sampling method. However, at least four samples from the main sources that supply large population groups were collected in each city.

The results presented in table 10 give a rough estimation of the strontium-90 content of the milk consumed in Mexico. These results are low compared to the PHS milk network average of 14.4 μμc/liter for the third quarter 1962 but are comparable with those in Hawaii for the same period.

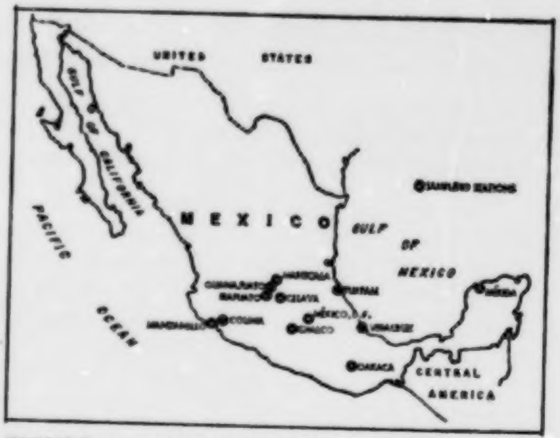

UNITED STATES
GULF OF CALIFORNIA
PACIFIC OCEAN
MEXICO
GULF OF MEXICO
SAMPLING STATIONS
GUANAJUATO
MARISCALA
IRAPUATO
CELAYA
TUXPAM
MANZANILLO
COLIMA
MEXICO, D.F.
CHALCO
VERACRUZ
OAXACA
MERIDA
CENTRAL AMERICA

FIGURE 14.—MEXICAN PASTEURIZED MILK SAMPLING STATIONS

TABLE 10.—STRONTIUM-90 IN MEXICAN PASTEURIZED MILK, MARCH–OCTOBER 1962

[Monthly Averages]

Month (1962)	Sampling location	Calcium (g/liter)	Strontium-90 (μμc/liter)	Strontium-90 (μμc/g Ca)
March	México, D. F.*	—	1.0	—
April	México, D. F.	—	1.7	—
	Veracruz	—	20.0	—
May	México, D. F.	—	2.5	—
	Oaxaca	—	2.7	—
June	México, D. F.	1.0	1.4	1.4
	Guanajuato	1.0	2.1	2.1
July	México, D. F.	1.4	1.6	1.1
	Mariscala	1.0	1.0	1.0
	Chalco	1.0	2.4	2.5
	Colima	1.0	1.0	1.0
August	México, D. F.	1.0	2.3	2.3
	Manzanillo	1.2	2.0	1.8
	Celaya	1.1	2.8	2.6
	Irapuato	1.0	1.0	1.0
	Colima	1.0	1.0	1.0
September	México, D. F.	1.1	1.0	1.0
	Mérida	0.9	3.2	3.6
October	México, D. F.	1.1	2.5	2.3
	Tuxpam	1.2	1.5	1.3

* Mexico City.

37

Twelve-Month Sum of Daily Radionuclide Content of One Liter of Pasteurized Milk

Iodine–131: February 1962–January 1963
Strontium–89 and strontium–90: January 1962–December 1962
Division of Radiological Health, Public Health Service

The guidance of the Federal Radiation Council (FRC) is given in terms of transient rates of intake of radioactive materials in micromicrocuries per day. The action ranges as proposed in FRC Report No. 2 are based on radiation doses considered acceptable for lifetime exposure from normal peacetime atomic industry operations (*1*). The Council recommends the use of a time period of one year as an appropriate interval for averaging exposures and emphasizes that the annual acceptable exposure dose is not a "danger point" which, if exceeded, requires protective measures (*1, 2, 3*).

To facilitate comparison of the concentrations of certain radionuclides in milk with the Radiation Protection Guides, tables 1 and 2 below furnish a means towards estimating the contribution of milk to the total dietary intake of iodine–131, strontium–89, and strontium–90. The tables are developed from the PHS Pasteurized Milk Network monthly averages of the nuclides. They present index values which are the estimated sum of the daily amounts of a radionuclide in one liter of milk for a 12-month period.

The tables show 12-month index values for each of the Network's 62 sampling locations. Due to the longer time required for strontium–89 and strontium–90 analysis, these 12-month index values are for the year beginning one month earlier than the iodine–131 values. The columns of monthly index values in each table are used to compute the net change as the yearly index values are advanced by one month. The following column shows this new 12-month index value. In addition, the first column in table 1 gives the iodine–131 January 1963 concentration averages.

The data in tables 1 and 2 are calculated as follows: (a) results from all samples collected in each week (Sunday through Saturday) are averaged, (b) the weekly averages for all weeks ending within a given month are averaged and an average for the month is obtained, and (c) the monthly radionuclide index value is determined by multiplying the average for the month by the number of days in the month. The number of days in the month will be either 28 or 35, corresponding to the complete calendar weeks used for any month. Procedures exemplified by (a) and (b) above minimize the effect of any one day's sample results on the average for the month, particularly for a short-lived radionuclide such as iodine–131. The moving index value is obtained by the following procedure. In column (A) are the twelve-month index values for the period indicated. In columns (B) and (C) are the monthly index values for the period indicated. The values in column (D) are obtained by adding the values in column (B) to those in column (A) and subtracting those in (C).

For a number of reasons it is desirable to have a standard quantity of milk to use in the development of index values for the different radionuclides. When one is concerned with strontium, 1 liter is a suitable quantity, as this amount of milk supplies approximately 1 gram of calcium, the amount used by the Federal Radiation Council in deriving the intake guidance for strontium. When one is concerned with iodine–131, the critical age group is the young infant. Available information suggests that the average milk consumption of infants in the 6–18 month group is not more than 1 liter per day. Thus the index value based on 1 liter of milk, though not directly an average intake value, is probably the most useful index for estimating total intake.

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(*1*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U.S. Government Printing Office (September 1961), price 20 cents.

(*2*) Chadwick, Donald R., and Conrad P. Straub: Considerations in Establishing Radiation Protection Standards for Radioactivity in the Environment, *Radiological Health Data, 3*:159–65, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (May 1962).

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TABLE 1.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF IODINE-131 IN ONE LITER OF MILK

Sampling locations		Jan. 1963 iodine-131 averages (μμc/liter)	Iodine-131 index values (μμc day/liter) [a]			
			Jan. 1962–Dec. 1962 (A)	Jan. 1962 (B)	Dec. 30, 1962–Jan. 26, 1963 (C)	Feb. 1962–Jan. 1963 (D)
Ala:	Montgomery	10	6,450	140	280	6,590
Alaska:	Palmer	20	37,800	140	560	38,220
Ariz:	Phoenix	10	4,260	270	280	4,270
Ark:	Little Rock	40	13,270	140	1,120	14,250
Calif:	Sacramento	30	4,350	140	840	5,050
	San Francisco	20	4,920	540	560	4,940
Colo:	Denver	20	5,570	270	560	5,860
Conn:	Hartford	<10	7,670	140	140	7,670
Del:	Wilmington	<10	11,730	140	140	11,730
D.C:	Washington	<10	8,440	140	140	8,440
Fla:	Tampa	20	5,820	140	560	6,240
Ga:	Atlanta	20	8,480	140	560	8,900
Hawaii	Honolulu	20	4,410	140	560	4,830
Idaho:	Idaho Falls	20	9,240	140	560	9,660
Ill:	Chicago	<10	13,690	140	140	13,690
Ind:	Indianapolis	10	11,870	140	280	12,010
Iowa:	Des Moines	20	21,550	270	560	21,840
Kans:	Wichita	20	21,450	270	560	21,740
Ky:	Louisville	<10	10,540	140	140	10,540
La:	New Orleans	20	8,480	140	560	8,900
Maine:	Portland	10	8,020	140	280	8,160
Md:	Baltimore	<10	8,690	140	140	8,690
Mass:	Boston	<10	7,950	140	140	7,950
Mich:	Detroit	10	12,680	140	280	12,820
	Grand Rapids	10	9,280	140	280	9,420
Minn:	Minneapolis	20	15,750	140	560	16,170
Miss:	Jackson	30	8,410	140	840	9,110
Mo:	Kansas City	10	30,370	270	280	30,380
	St. Louis	20	12,110	140	560	12,530
Mont:	Helena	20	14,490	140	560	14,910
Nebr:	Omaha	20	19,110	140	560	19,530
Nev:	Las Vegas [b]	<10	3,960	[c]—	140	4,100
N.H:	Manchester	<10	7,290	140	140	7,290
N.J:	Trenton	<10	7,990	140	140	7,990
N. Mex:	Albuquerque	10	7,450	270	280	7,460
N.Y:	Buffalo	<10	8,720	140	140	8,720
	New York	<10	11,660	140	140	11,660
	Syracuse	<10	9,980	140	140	9,980
N.C:	Charlotte	<10	3,370	140	140	3,370
N.D:	Minot	10	14,770	140	280	14,910
Ohio:	Cincinnati	10	14,320	140	280	14,460
	Cleveland	<10	11,100	140	140	11,100
Okla:	Oklahoma City	30	17,540	140	840	18,240
Oreg:	Portland	10	9,630	140	280	9,770
Pa:	Philadelphia	10	10,680	140	280	10,820
	Pittsburgh	<10	14,670	140	140	14,670
P.R:	San Juan [d]	30	4,560	140	840	5,260
R.I:	Providence	<10	8,440	140	140	8,440
S.C:	Charleston	20	6,170	140	560	6,590
S.D:	Rapid City	20	14,110	140	560	14,530
Tenn:	Chattanooga	<10	7,850	140	140	7,850
	Memphis	20	9,630	140	560	10,050
Tex:	Austin	30	10,340	140	840	11,040
	Dallas	30	17,720	140	840	18,420
Utah:	Salt Lake City	20	31,630	270	560	31,920
Vt:	Burlington	<10	8,380	140	140	8,380
Va:	Norfolk	<10	6,410	140	140	6,410
Wash:	Seattle	20	9,650	270	560	9,940
	Spokane	20	21,350	140	560	21,770
W. Va:	Charleston	<10	6,830	140	140	6,830
Wis:	Milwaukee	<10	14,320	140	140	14,320
Wyo:	Laramie	10	19,840	270	280	19,850

[a] The data in this table are index values, not to be interpreted as consumption or total intake values. Annual iodine-131 intake per person from milk may be calculated from an index value in this table by applying the appropriate factor representing average individual daily milk consumption for any selected group under consideration.

Example: (12-month I^{131} index) × (milk consumption factor) = (12-month I^{131} intake)
(μμc day/liter) (liter/day/person) (μμc/person)

[b] Station included in network in July 1962. Sums in columns A and D are therefore for 6 and 7 months, respectively.
[c] A dash indicates no analysis.
[d] No sample was received in November 1962. Sums in columns A and D are therefore for 11 months.

TABLE 2.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF STRONTIUM-89 AND STRONTIUM-90 IN ONE LITER OF MILK

Sampling locations		Strontium-89 index values (μμc day/liter)[a]				Strontium-90 index values (μμc day/liter)[a]			
		Dec. 1961–Nov. 1962 (A)	Dec. 1961 (B)	Nov.25,1962–Dec. 29, 1962 (C)	Jan. 1962–Dec. 1962 (D)	Dec. 1961–Nov. 1962 (A)	Dec. 1961 (B)	Nov.25,1962–Dec. 29, 1962 (C)	Jan. 1962–Dec. 1962 (D)
Ala:	Montgomery	19,905	620	2,100	21,385	4,950	186	560	5,324
Alaska:	Palmer	17,885	620	1,400	18,665	3,501	279	385	3,607
Ariz:	Phoenix	6,490	620	700	6,570	1,067	62	140	1,145
Ark:	Little Rock	44,550	2,635	6,300	48,215	10,068	527	1,120	10,661
Calif:	Sacramento	6,515	310	700	6,905	1,316	93	140	1,363
	San Francisco	10,850	465	1,225	11,610	1,844	124	175	1,895
Colo:	Denver	10,685	775	525	10,435	3,361	217	385	3,529
Conn:	Hartford	7,610	310	700	8,000	3,833	217	245	3,861
Del:	Wilmington	12,555	620	1,050	12,985	4,544	270	525	4,799
D.C:	Washington	12,295	620	875	12,550	4,817	248	595	5,164
Fla:	Tampa	7,890	310	1,400	8,980	3,326	217	350	3,459
Ga:	Atlanta	28,845	1,240	2,975	30,580	6,178	372	595	6,401
Hawaii:	Honolulu	9,440	620	1,050	9,870	1,989	341	210	1,858
Idaho	Idaho Falls	8,360	155	525	8,730	2,926	186	490	3,230
Ill:	Chicago	10,215	465	1,050	10,800	3,788	217	315	3,886
Ind:	Indianapolis	13,115	620	1,225	13,720	4,732	310	350	4,772
Iowa:	Des Moines	23,295	1,550	1,925	23,670	4,219	248	490	4,461
Kans:	Wichita	17,850	1,240	1,575	18,185	3,881	310	525	4,096
Ky:	Louisville	25,690	1,550	3,500	27,640	6,671	341	700	7,030
La:	New Orleans	64,820	6,355	3,325	61,790	10,401	527	980	10,854
Maine:	Portland	10,355	80	525	10,800	4,763	341	560	4,982
Md:	Baltimore	11,695	930	1,050	11,815	5,057	248	595	5,404
Mass:	Boston	10,845	80	525	11,290	5,477	341	595	5,731
Mich:	Detroit	9,725	465	525	9,785	3,757	186	385	3,956
	Grand Rapids	8,290	465	525	8,350	3,492	217	315	3,590
Minn:	Minneapolis	19,880	620	875	20,135	5,323	310	805	5,818
Miss:	Jackson	55,930	5,425	5,425	55,930	8,427	527	840	8,740
Mo:	Kansas City	28,825	2,170	3,850	30,505	4,852	372	665	5,145
	St. Louis	18,145	620	1,575	19,100	4,601	248	490	4,843
Mont:	Helena	14,955	155	1,225	16,025	3,829	186	560	4,203
Nebr:	Omaha	21,160	2,170	1,750	20,740	4,233	217	560	4,576
Nev:	Las Vegas [b]	3,885	[c]—	875	4,760	819	—	175	994
N.H:	Manchester	9,975	155	525	10,345	4,919	372	525	5,072
N.J:	Trenton	9,515	465	875	9,925	3,950	248	280	3,982
N. Mex:	Albuquerque	5,425	310	1,050	6,165	1,525	124	210	1,611
N.Y:	Buffalo	8,400	155	525	8,770	4,003	248	350	4,105
	New York	10,010	155	700	10,555	4,845	279	385	4,951
	Syracuse	9,010	155	700	9,555	3,774	217	385	3,942
N.C:	Charlotte	19,715	930	1,575	20,360	6,493	372	735	6,856
N. Dak:	Minot	17,490	1,995	875	16,370	5,885	341	1,155	6,699
Ohio:	Cincinnati	17,155	1,550	1,750	17,355	5,067	310	490	5,247
	Cleveland	10,095	310	875	10,660	4,031	217	420	4,234
Okla:	Oklahoma City	24,460	2,170	3,150	25,440	5,611	279	665	5,997
Ore:	Portland	25,150	620	5,075	29,605	4,373	124	630	4,879
Pa:	Philadelphia	9,465	310	1,050	10,205	4,387	279	385	4,493
	Pittsburgh	10,970	155	1,400	12,215	5,366	310	490	5,546
P.R:	San Juan [d]	23,400	4,030	4,550	23,920	3,029	155	455	3,329
R.I:	Providence	8,920	465	525	8,980	4,415	279	385	4,521
S.C:	Charleston	22,385	465	2,800	24,720	6,399	372	805	6,832
S. Dak:	Rapid City [e]	18,560	—	1,225	19,785	4,782	—	700	5,482
Tenn:	Chattanooga	40,190	2,480	4,725	42,435	7,507	496	840	7,851
	Memphis	36,970	2,635	3,850	38,185	7,259	372	700	7,587
Tex:	Austin	9,625	2,015	2,625	10,235	2,394	186	350	2,558
	Dallas	22,750	1,860	6,825	27,715	4,888	248	665	5,305
Utah:	Salt Lake City	10,525	465	875	10,935	2,971	155	350	3,166
Vt:	Burlington	10,425	155	700	10,970	3,964	248	350	4,066
Va:	Norfolk	16,945	1,240	1,400	17,105	5,986	341	700	6,345
Wash:	Seattle	20,510	930	1,925	21,505	5,191	248	490	5,433
	Spokane	12,385	155	875	13,105	4,075	217	595	4,453
W. Va:	Charleston	20,180	620	1,225	20,785	6,267	341	665	6,591
Wis:	Milwaukee	7,700	155	700	8,245	2,952	186	280	3,046
Wyo:	Laramie	17,495	155	1,400	18,740	3,287	155	420	3,552

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[a] The data in this table are index values, not to be interpreted as consumption or total intake values. Annual strontium-89 and strontium-90 intake per person from milk may be calculated from an index value in this table by applying the appropriate factor representing average individual daily milk consumption for any selected group under consideration.

Example: (12-month Sr^{89} or Sr^{90} index) (μμc day/liter) × (milk consumption factor) (liter/day/person) = (12-month Sr^{89} or Sr^{90} intake) (μμc/person)

[b] Station included in network in July 1962. Sums in columns A and D are therefore for 5 and 6 months, respectively.

[c] A dash indicates no analysis.

[d] No sample was received for November 1962. Sums are therefore for eleven months.

[e] Station began operation in January 1962. December 1961–November 1962 sum is therefore for 11 months.

SECTION IV.—WATER

Radioactivity in Raw Surface Waters

NATIONAL WATER QUALITY NETWORK
October 1962

Division of Water Supply and Pollution Control, Public Health Service

The National Water Quality Network, operated by the Public Health Service in cooperation with State and local agencies since 1957, consisted of 123 sampling stations as of the end of October (figure 1). These stations are located on the major waterways used for public water supplies, propagation of fish and wildlife, and recreational, agricultural, and industrial purposes. Samples are taken weekly, monthly, or continuously, depending on the type of analysis and the water quality. These samples are analyzed for plankton population, organic chemicals, chemical, biological, and physical quality, and radioactivity (*1, 2*).

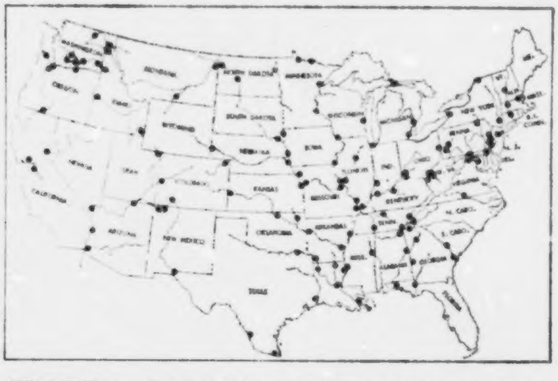

FIGURE 1.—NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS, OCTOBER 1962

The radioactivity associated with dissolved solids provides a rough measure of the levels which may be found in treated water, since nearly all of the suspended matter is removed by treatment processes (*3*). It has been observed that in water the natural environmental beta activity is usually several times that of the natural environmental alpha activity. Nuclear installations may contribute additional alpha or beta activity whereas fallout contributes primarily additional beta activity. Gross alpha and beta measurments are made on both suspended and dissolved solids (strontium-90 on the total solids only) in raw surface water samples according to established procedures (*4, 5*). Because strontium-90 analyses are done quarterly, the results are published on this basis.

For the first two years, beta determinations were made on weekly samples, and alpha determinations were generally made on composites of more than weekly samples. From January 1960 to September 1961, alpha and beta determinations were generally made once a month on weekly composited samples. Begin-

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS

[Average concentrations in pc/liter]

Station	October 1962					
	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River: Pittsburgh, Pa	4	15	19	0	0	0
Animas River: Cedar Hill, N. Mex	5	36	41	2	5	7
Apalachicola River: Chattahoochie, Fla	4	4	8	0	0	0
Arkansas River:						
Coolidge, Kans	6	142	148	0	14	14
Ponca City, Okla	84	44	128	—	—	—
Pendleton Ferry, Ark	—	—	—	—	—	—
Bear River: Preston, Idaho	16	18	34	0	2	2
Big Horn River: Hardin, Mont	27	20	47	5	8	13
Big Sioux River: Sioux Falls, S. Dak	9	26	35	0	3	3
Chattahoochie River:						
Atlanta, Ga	5	5	10	0	0	0
Columbus, Ga	—	—	—	—	—	—
Lanett, Ala	8	10	18	1	0	1
Chena Slough: Fairbanks, Alaska	2	10	12	0	1	1
Clear Water River: Lewiston, Idaho	33	27	60	—	—	—
Clinch River:						
Kingston, Tenn	37	215	252	0	0	0
Clinton, Tenn	11	12	23	0	1	1
Colorado River:						
Loma, Colo	22	47	69	3	9	12
Page, Ariz	—	—	—	—	—	—
Boulder City, Nev	5	34	39	0	11	11
Parker Dam, Calif.-Ariz	6	34	40	0	4	4
Yuma, Ariz	92	16	108	—	—	—
Columbia River:						
Northport, Wash	1	11	12	<1	<1	1
Wenatchee, Wash	0	6	6	0	0	0
Pasco, Wash	32	193	225	0	2	2
McNary Dam, Ore	25	177	202	0	2	2
Bonneville, Ore	—	—	—	—	—	—
Clatskanie, Ore	8	22	30	—	—	—
Connecticut River:						
Wilder, Vt	16	15	21	0	0	0
Northfield, Mass	11	8	19	—	—	—
Enfield Dam, Conn	5	14	19	0	0	0
Cumberland River: Clarksville, Tenn	3	11	14	—	—	—
Delaware River:						
Martins Creek, Pa	6	12	18	—	—	—
Trenton, N. J	16	16	32	0	0	0
Philadelphia, Pa	5	15	20	—	—	—
Escambia River: Century, Fla	—	—	—	—	—	—
Great Lakes:						
Duluth, Minn	1	15	16	0	0	0
Sault Ste. Marie, Mich	2	6	8	0	1	1
Milwaukee, Wis	12	6	18	0	0	0
Gary, Ind	2	7	9	0	0	0
Port Huron, Mich	7	10	17	0	1	1
Detroit, Mich	3	15	18	0	0	0
Buffalo, N. Y	15	9	24	—	—	—
Green River: Dutch John, Utah	19	26	45	0	3	3
Hudson River: Poughkeepsie, N. Y	4	13	17	—	—	—
Illinois River:						
Peoria, Ill	13	24	37	1	0	1
Grafton, Ill	20	24	44	2	<1	2
Kanawha River: Winfield Dam, W. Va	7	5	12	—	—	—
Klamath River: Keno, Ore	—	—	—	—	—	—
Little Miami River: Cincinnati, Ohio	14	31	45	0	2	2
Mississippi River:						
St. Paul, Minn	10	19	29	—	—	—
Dubuque, Iowa	10	16	26	1	3	4
Burlington, Iowa	15	27	42	1	0	1
E. St. Louis, Ill	10	24	34	0	0	0
Cape Girardeau, Mo	72	25	97	4	3	7
W. Memphis, Ark	26	23	49	0	0	0
Delta, La	30	14	44	2	1	3
New Orleans, La	3	20	23	—	—	—
Vicksburg, Miss	24	16	40	2	1	3
Missouri River:						
Williston, N. Dak	32	22	54	—	—	—
Bismarck, N. Dak	12	31	43	0	3	3
Yankton, S. Dak	12	71	83	0	11	11
Omaha, Nebr	10	29	39	—	—	—
St. Joseph, Mo	20	28	48	—	—	—
Kansas City, Kans	31	31	62	9	2	11
St. Louis, Mo	138	36	174	—	—	—
Missouri City, Mo	30	6	36	3	3	6
Rio Grande River:						
Alamoso, Colo	17	37	54	0	3	3
El Paso, Tex	—	—	—	—	—	—
Laredo, Tex	112	12	124	18	9	27
Brownsville, Tex	—	—	—	—	—	—
Roanoke River: John H. Kerr Resr. & Dam, Va	8	15	23	0	0	0
Sabine River: Ruliff, Tex	6	8	14	0	0	0
Sacramento River: Greens Landing, Courtland, Calif	4	10	14	0	1	1
San Joaquin River: Vernalis, Calif	7	22	29	<1	4	4
San Juan River: Shiprock, N. Mex	5	15	20	0	6	6
St. Lawrence River: Massena, N. Y	3	9	12	—	—	—
Schuylkill River: Philadelphia, Pa	6	18	24	—	—	—
Savannah River:						
North Augusta, S. C	2	13	15	—	—	—
Port Wentworth, Ga	5	7	12	0	0	0

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TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS—Continued

[Average concentrations in pc/liter]

Station	October 1962					
	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Shenandoah River: Berryville, Va.	15	24	39	0	1	1
Ship Creek: Anchorage, Alaska	6	13	19	0	0	0
Monongahela River: Pittsburgh, Pa.	4	29	33	—	—	—
North Platte River: Henry, Nebr.	16	48	64	0	20	20
Ohio River:						
E. Liverpool, Ohio	—	—	—	—	—	—
Addison, Ohio	12	28	40	<1	0	<1
Huntington, W. Va.	6	21	27	—	—	—
Cincinnati, Ohio	13	26	39	0	0	0
Louisville, Ky	8	22	30	—	—	—
Evansville, Ind	2	15	17	1	3	4
Cairo, Ill	5	21	26	0	1	1
Ouachita River: Bastrop, La.	21	17	38	0	0	0
Pend Oreille River: Albeni Falls Dam, Idaho	4	11	15	0	<1	<1
Platte River: Plattsmouth, Nebr.	17	26	43	4	2	6
Potomac River:						
Williamsport, Md	—	—	—	—	—	—
Great Falls, Md	2	12	14	—	—	—
Rainy River:						
Baudette, Minn	5	26	31	0	0	0
International Fls., Minn	3	18	21	0	0	0
Red River, South:						
Index, Ark	20	52	72	—	—	—
Alexandria, La	53	56	109	1	2	3
	41	22	63	0	0	0
Snake River:						
Ice Harbor Dam, Wash	5	22	27	0	1	1
Wawawai, Wash	15	22	37	0	2	2
Payette, Idaho	7	18	25	0	3	3
South Platte River: Julesburg, Colo	30	104	134	2	55	57
Spokane River: Post Falls, Idaho	11	7	18	0	0	0
Susquehanna River:						
Sayre, Pa	12	23	35	—	—	—
Conowingo, Md	2	12	14	—	—	—
Tennessee River:						
Chattanooga, Tenn	6	20	26	0	0	
Bridgeport, Ala	—	—	—	—	—	—
Pickwick Landing, Tenn	7	21	28	1	0	1
Lenoir City, Tenn	4	10	14	0	<1	<1
Tombigbee River: Columbus, Miss	11	16	27	0	2	2
Truckee River: Farad, Calif	—	—	—	—	—	—
Verdigris River: Nowata, Okla	33	25	58	<1	<1	1
Wabash River: New Harmony, Ind	23	74	97	1	<1	1
Yakima River: Richland, Wash	10	14	24	0	1	1
Yellowstone River: Sidney, Mont	150	26	176	3	3	6

ning in September 1961, alpha determinations have been made on one sample each month, and beta determinations have generally been made on weekly samples. For the first operating year of each new station, sampling, and alpha and beta analysis are done weekly.

If at any time activity significantly greater than the normal environmental levels has been noted, the rate of sampling and analysis has been increased to at least one every week. Since January 1959, a portion of each sample from all stations in the network has been composited into a three-month station sample for measurement of strontium–90 (*6*).

Table 1 presents the results of the alpha and beta analyses on raw surface water in the United States for October 1962.

REFERENCES

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(*2*) Setter, L. R., and S. L. Baker: Radioactivity of Surface Waters in the United States, *Radiological Health Data, 1*:20–31 (October 1960).

(*3*) Straub, C. P.: Significance of Radioactivity Data, *Journal of the American Water Works Association, 53*:704 (June 1961).

(*4*) Setter, L. R., J. E. Regnier, and E. A. Diephaus: Radioactivity of Surface Waters in the United States, *Journal of the American Water Works Association, 51*:1377 (November 1959).

(*5*) Robert A. Taft Sanitary Engineering Center, Public Health Service: *Radionuclide Analysis of Environmental Samples, Technical Report, R59–6* (1959).

(*6*) Straub, C. P., L. R. Setter, A. Goldin, and P. F. Hallbach: Strontium–90 in Surface Waters in the U.S., *Journal of the American Water Works Association, 52*:756 (June 1960).

RADIOACTIVITY IN CALIFORNIA SURFACE WATER
1961–June 1962

Bureau of Radiological Health
State of California,
Department of Public Health

In March 1960 the Bureau of Radiological Health was formed in California's Division of Environmental Sanitation. This Bureau is responsible for environmental radiation surveillance.

The Bureau was established in recognition of the need for baseline data and continuing monitoring in order to pinpoint environmental radiation problems well before a level of acute concern is reached. Domestic water was one item selected for monitoring by the Bureau.

Procedure

Most of California's domestic water supplies come from surface sources. Radioactivity in such water supplies consists of the natural radioactivity in surface streams and any radioactivity that may be added by the discharge of sewage or industrial waste effluents into streams. These water supplies may also contain radioactivity from fallout, particularly fallout into open terminal or distribution reservoirs. Most of the supplies sampled represent raw surface waters (see figure 2) although a few wells, along with some water supplies that use infiltration galleries, are also sampled.

It is necessary to monitor domestic water supplies on a continuous basis, since it is impossible to forecast levels of radioactivity in these supplies on the basis of radioactivity in rain, snow, or surface streams. The California Bureau has established a monthly sampling schedule whereby 500 ml samples are collected and the total solids are analyzed for alpha and beta radioactivity. In addition, a three-liter sample is collected each month for a period of six months to make up a composite of approximately five gallons for strontium-90 analysis.

Laboratory Methods

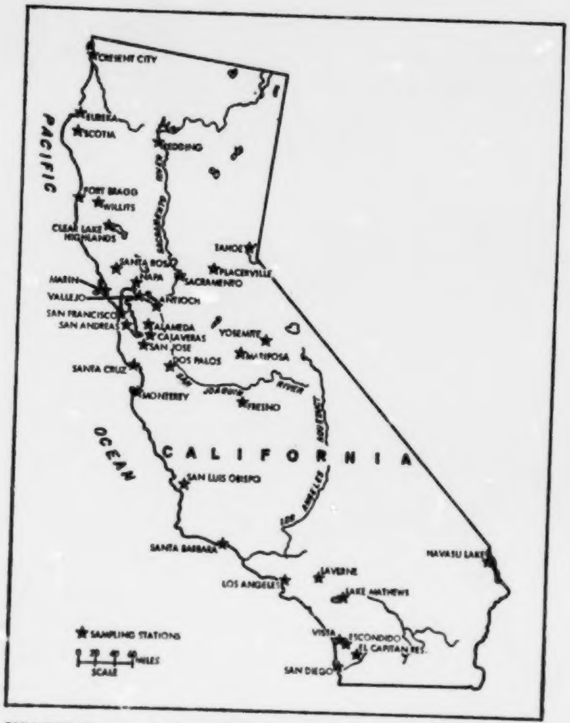
CRESENT CITY
EUREKA
SCOTIA
REDDING
PACIFIC
FORT BRAGG
WILLITS
CLEAR LAKE HIGHLANDS
TAHOE
SANTA ROSA
PLACERVILLE
NAPA
SACRAMENTO
MARIN
VALLEJO
ANTIOCH
SAN FRANCISCO
SAN ANDREAS
ALAMEDA
CALAVERAS
SAN JOSE
YOSEMITE
MARIPOSA
DOS PALOS
SANTA CRUZ
SAN JOAQUIN RIVER
MONTEREY
FRESNO
OCEAN
C A L I F O R N I A
SAN LUIS OBISPO
LOS ANGELES
SANTA BARBARA
NAVASU LAKE
LOS ANGELES
LAVERNE
LAKE MATHEWS
SAMPLING STATIONS
VISTA
ESCONDIDO
EL CAPITAN RES.
0 20 40 60 MILES
SCALE
SAN DIEGO

FIGURE 2.—CALIFORNIA SURFACE WATER SAMPLING STATIONS

All measurements of alpha and alpha plus beta activities are made with windowless, gas-flow, proportional counters. These counting devices have two decided advantages: (1) windowless counting provides geometry, thereby 2π giving efficiencies of about 60 percent for thallium-204 or cesium-137 sources, both of which have been used for calibration, and (2) proportional counters can be used to separately measure alpha and beta radioactivity by simply adjusting the high voltage, thus eliminating the need for two types of detectors.

Five proportional counters, four of which are manual counters, are available to the California Bureau. The manual counters accept samples up to two inches in diameter. Two of these manual units have shielded external detectors which reduce the alpha and beta backgrounds to 0.01 and 30 cpm respectively. The other two manual counters are of integral construction with the unshielded detector built into the scaler housing. The relatively high beta background of these units has been reduced to 40 cpm by shielding the entire scaler with lead bricks.

The fifth counter is an automatic unit composed of a sample changer, detector, scaler, and a printer-timer. The detector accepts samples

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up to 1½ inches in diameter and has a beta background of about 15 cpm.

The Bureau's maximum capacity for alpha and beta radioactivity measurements during a normal work week is 500 thirty-minute counts.

Discussion

Tables 2 and 3 show the monthly average beta activity in the suspended plus the dissolved solids in raw surface water in California from January 1961 through June 1962. Following treatment, these waters are used for industrial and domestic purposes. Because alpha activity in water has been, in general, not detectable or very slight, the results of alpha activity analyses are not presented.

Data from the years 1961 and 1962 for a few selected sampling points in different parts of the State are presented in Table 4. The data in this table are six-month averages. California annually experiences both a wet and a dry season with an accompanying heavy or light runoff, respectively. The period January through June corresponds to the wet season with the balance of the year being the dry season. If the dry seasons of 1961 and 1962 are compared, or if the wet seasons of 1961 and 1962 are similarly compared, it may be observed that there was a general increase in beta activity from 1961 to 1962. Although the increases are significant statistically, the levels do not represent any significant health hazard.

TABLE 2.—GROSS BETA ACTIVITY IN CALIFORNIA SURFACE WATER, 1961

[Concentrations in μμc/liter]

Sampling station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Antioch	[a]	3.6	20.5	10.2	7.4	[a]	8.5	13.1	[a]	[a]	24.3	22.0
Clearlake Highlands	[a]	[a]	[a]	8.3	8.8	12.3	16.5	14.4	14.4	16.2	12.4	17.9
Dos Palos	[a]	[a]	[a]	14.2	[b] —	—	[a]	17.7	—	5.4	—	—
Escondido	—	—	4.5	13.5	15.3	13.5	—	[a]	[a]	19.9	49.4	34.5
Eureka	[a]	[a]	3.8	[a]	98.8	[a]	4.3	—	—	6.0	74.2	45.2
Fort Bragg	[a]	[a]	[a]	[a]	43.1	2.7	3.3	[a]	3.6	31.7	5.9	47.1
Fresno												
Lake Millerton	[a]	[a]	23.4	56.9	53.7	2.5	3.7	7.2	[a]	[a]	23.6	17.7
Los Angeles Metropolitan Water District												
Lake Havasu	11.6	[a]	47.2	32.0	30.9	12.0	—	—	109.8	15.8	—	27.2
Lake Matthews	—	—	—	—	27.8	3.8	13.8	[a]	16.2	[a]	[a]	18.2
Marin Municipal Water District												
Alpine Dam	2.9	[a]	[a]	[a]	2.8	21.2	—	3.8	—	—	37.7	—
Mill Valley Reservoir	[a]	[a]	[a]	[a]	3.6	3.5	[a]	[a]	—	13.1	—	—
North Marin County Water District	8.8	7.3	5.4	8.2	42.3	34.0	10.3	12.4	—	18.1	37.8	—
Monterey	[a]	[a]	7.7	15.6	[a]	[a]	[a]	[a]	[a]	11.3	[a]	32.8
Napa	—	[a]	[a]	19.7	28.4	70.1	5.5	[a]	4.7	27.1	[a]	25.8
Placerville	8.0	[a]	34.5	42.7	[a]	4.6	—	16.1	12.3	[a]	—	73.4
Redding	[a]	[a]	[a]	6.1	31.2	4.5	10.0	[a]	[a]	6.7	—	21.7
Sacramento	2.9	6.8	9.8	12.6	—	—	9.5	16.1	[a]	20.2	13.7	29.8
San Diego												
Alvarado Filter Plant	[a]	[a]	[a]	19.0	26.0	14.2	18.3	—	14.6	22.2	31.7	15.8
El Capitan Reservoir	8.2	5.7	3.3	—	29.6	—	—	—	14.3	87.9	—	—
Sutherland Reservoir	8.7	8.8	4.9	—	32.1	—	—	—	23.3	—	33.5	—
San Francisco Water Department												
University Mount	[a]	[a]	4.4	9.3	—	5.0	11.4	[a]	2.8	17.9	40.7	22.0
Calaveras Reservoir	[a]	1.9	[a]	50.5	4.1	[a]	9.1	[a]	15.8	5.7	57.1	24.2
Alameda East	[a]	[a]	[a]	77.6	6.7	9.9	7.0	[a]	15.8	14.0	33.9	11.0
San Andreas Line #1	[a]	[a]	2.9	10.5	—	3.9	[a]	[a]	—	—	57.2	—
San Francisco Water Department, Con												
San Andreas Line #2	[a]	[a]	4.8	5.5	—	[a]	[a]	[a]	3.6	22.0	41.1	41.6
Crystal Springs Reservoir	[a]	[a]	[a]	3.7	—	4.5	7.6	[a]	[a]	13.1	28.7	25.4
Crystal Springs Line #1	[a]	[a]	5.0	39.9	—	6.5	6.3	[a]	4.8	[a]	36.9	24.6
Lombard Reservoir	[a]	[a]	[a]	14.1	3.4	5.2	[a]	[a]	[a]	[a]	30.3	12.1
San Jose	[a]	[a]	[a]	40.4	71.6	[a]	9.5	[a]	—	—	—	—
San Luis Obispo	—	—	—	—	11.8	7.4	82.0	[a]	5.8	19.6	11.4	54.5

[a] No significant activity.
[b] Dash indicates no sample collected or analyzed.

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TABLE 3.—GROSS BETA ACTIVITY I[illegible]LIFORNIA SURFACE WATER, 1962

[Concentrations in μ[illegible]

Sampling station	Jan	Feb	Mar	Apr	May	Jun
Antioch	36.2	88.2	31.9	27.9	7.3	16.7
Clearlake Highlands	24.0	249.8	55.4	47.2	26.8	23.4
Crescent City	[a]	[a]	11.1	25.2	19.6	27.6
Escondido	34.7	81.2	[b]—	43.6	45.9	22.2
Eureka	72.7	58.1	29.8	38.6	4.2	21.1
Fort Bragg	47.2	31.5	218.1	30.8	—	9.9
Fresno						
Lake Millerton	[c]20.7	[c]58.5	[c]33.0	[c]45.2	[c]44.2	[c]29.8
Los Angeles Metropolitan Water District						
Lake Havasu	—	35.1	23.9	27.7	—	—
Lake Matthews	29.0	26.1	37.1	37.8	19.3	—
LaVerne Treatment Plant	—	—	—	—	17.5	7.4
Marin Municipal Water District	27.5	36.3	43.8	—	46.7	29.7
North Marin County Water District	—	—	69.8	60.5	31.8	46.2
Mariposa	—	34.8	40.0	18.0	45.3	31.5
Monterey	20.8	[a]	67.6	[a]	10.6	7.0
Napa	22.4	38.3	41.6	20.9	30.3	29.2
Placerville	[a]	49.6	22.6	28.3	35.7	7.0
Redding	[c]27.6	27.0	48.9	35.6	28.4	42.4
Sacramento	[a]	41.7	—	11.9	13.6	12.5
San Francisco Water Department						
University Mount	29.5	49.4	—	59.8	37.5	30.8
Calaveras Reservoir	24.0	37.9	35.6	37.8	35.1	19.2
Alameda East	[a]	40.1	1.7	45.8	31.9	47.8
San Andreas Line #2	12.6	[c]60.5	[c]56.7	[c]34.2	[c]24.0	[c]31.9
Crystal Springs Line #1	—	29.9	[c]33.2	[c]42.8	18.6	[c]26.2
Crystal Springs Line #2	13.4	[c]23.1	—	17.0	20.6	28.6
Crystal Springs Raw Outlet	—	27.7	77.2	47.8	42.9	24.2
Lombard Reservoir	50.4	76.6	46.0	14.1	29.9	—
Brightside Weir	—	17.5	34.0	102.9	40.6	[a]
Hetch Hetchy	—	—	—	—	62.2	56.2
San Jose	—	—	—	25.6	10.4	19.7
San Luis Obispo	[a]	33.3	114.7	6.5	58.5	20.2
Santa Barbara	67.9	26.0	[a]	16.7	—	40.3
Santa Cruz						
Coastal Water	[a]	269.0	83.0	34.1	[a]	1.8
Santa Rosa	[a]	—	33.8	23.1	1.7	[a]
Scotia	18.9	197.1	65.1	19.7	—	8.6
Tahoe City	16.1	[a]	64.2	47.5	30.4	17.2
Vallejo						
Fleming Hill	55.6	284.0	73.6	39.4	19.7	17.6
Swanzy Reservoir	[a]	63.9	15.4	35.2	35.3	21.6
Vista	61.5	81.2	48.6	22.2	70.9	25.2
Willits	60.2	104.1	21.6	43.8	36.3	26.2
Yosemite	[c]13.4	49.1	65.3	69.1	41.8	31.7

[a] No significant activity.
[b] Dash indicates no sample collected or analyzed.
[c] Average of more than one sample for the month.

TABLE 4.—SIX MONTH AVERAGE OF GROSS BETA RADIOACTIVITY IN RAW WATER IN SELECTED CALIFORNIA CITIES*

[Concentrations in μμc/liter]

City	Jan–June 1961	July–Dec. 1961	Jan–June 1962	July–Dec. 1962
Clearlake Highlands	4.9	15.3	35.4	17.8
Fort Bragg	7.6	15.3	29.9	37.3
Lake Millerton	22.8	8.7	38.6	14.0
Monterey	3.9	7.3	17.7	13.8
Placerville	15.0	25.5	23.9	12.3
Redding	7.0	7.7	35.0	19.0
Sacramento	8.0	14.9	15.9	9.2
San Jose	18.7	4.8	18.6	6.6

* Averages based on at least three monthly values.

Radioactivity in Minnesota Surface Water
April–November 1962

Division of Environmental Sanitation, Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity concentration was initiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies as well as selected lakes throughout the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled, but 7 surface streams and lakes involving 11 stations are now sampled routinely (see figure 3). Grab samples of raw and treated water are collected weekly at each station with the exception of the Crookston, Elk River, International Falls, and St. Cloud stations, where monthly samples are collected.

The samples are forwarded to the Division's laboratory where they are analyzed for gross beta activity. A 250 ml sample of water is evaporated at 75° C. from a planchet. The solid residue (suspended plus dissolved solids) is fixed by adding lucite in acetone. Afterwards, this sample is counted with either an internal proportional counter or a thin end-window

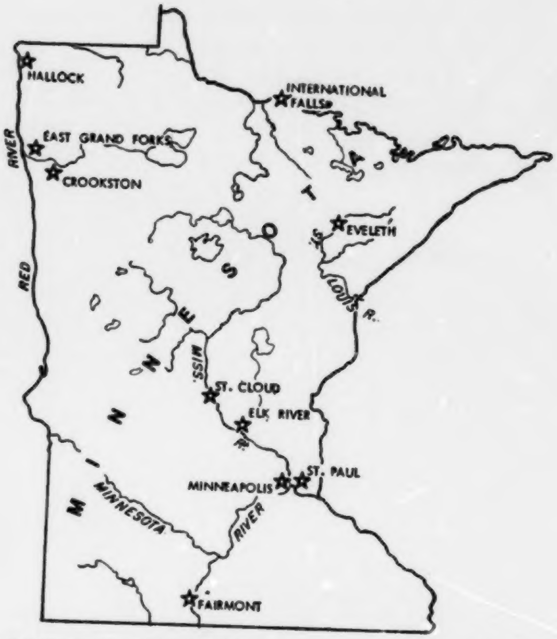

FIGURE 3.—MINNESOTA SURFACE WATER SAMPLING LOCATIONS

TABLE 5.—TOTAL BETA CONCENTRATION IN MINNESOTA RAW AND TREATED WATER FROM SURFACE SUPPLIES, APRIL–NOVEMBER 1962

[Concentration in $\mu\mu c$/liter]

Town and water source	Type of water	April	May	June	July	August	September	October	November
Crookston, Red Lake River	raw	[a]—	51	120	97	98	49	37	30
	treated	—	40	85	56	29	15	26	33
Elk River, Mississippi River	raw	—	—	—	—	32	58	—	—
	treated	—	—	—	—	—	—	—	—
East Grand Forks, Red Lake River	raw	79	104	112	55	42	42	36	35
	treated	44	43	55	51	12	28	17	18
Eveleth, St. Mary's Lake	raw	b	36	52	23	47	26	19	31
	treated	b	25	33	36	31	13	16	27
Fairmont, Budd Lake	raw	31	44	64	51	23	26	49	29
	treated	b	27	15	21	23	27	8	16
Hallock, Two Rivers South Fork	raw	69	94	135	151	78	64	43	68
	treated	41	42	55	89	27	39	16	50
International Falls, Rainy River	raw	—	15	47	77	49	—	47	33
	treated	—	b	22	44	b	—	36	24
Minneapolis Tap Water	raw	—	—	—	—	—	—	—	—
	treated	—	32	20	11	—	11	—	b
St. Cloud, Mississippi River	raw	—	b	96	35	—	b	b	24
	treated	—	20	44	42	—	b	b	b
St. Paul Vadnais Chain of Lakes	raw	b	b 58	59	45	44	47	40	10
	treated	b	b 13	8	49	21	27	6	7

[a] Dash indicates no analysis performed.
[b] Letter indicates nondetectable beta activity.

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proportional counter. Counter standardization is accomplished by adding known amounts of thallium-204 standard to solutions containing the normal range of solids.

Table 5 shows the monthly average gross beta activity in Minnesota surface water from April through November 1962. The nondetectable (ND) values shown indicate that the activity was indistinguishable from background. In averaging, ND values are assumed to be zero except when the values to be averaged consist of only ND values; then the average is reported as ND.

The data obtained on gross beta activity in Minnesota surface waters show a random variation of concentrations, with no readily apparent trends. Variation in precipitation and flow rates of streams could contribute to this variation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from nondetectable to 151 μμc/liter. Individual samples had concentrations that ranged from nondetectable to 220 μμc/liter.

SECTION V.—OTHER DATA

Tri-City Diet Study—Stable Strontium and Calcium Diet/Bone Observed Ratios, 1962*

Joseph Rivera
Health and Safety Laboratory, U.S. Atomic Energy Commission

One aspect of the program of investigation at the Health and Safety Laboratory on the passage of strontium-90 through food chains to man has been the determination of the concentrations of stable strontium present in the various components of the food chain and in man's skeleton. Estimates of stable strontium intake by residents of New York City, Chicago, and San Francisco were made in the last quarterly report (HASL–131) (*1*, *2*). The ratios of stable strontium to calcium in the diets from these cities were 1.5, 2.3 and 3.4 mg/g Ca, respectively.

An estimate of the degree of discrimination by the body between strontium and calcium can be made by comparing the ratio of these elements in the diet with the ratio found in bone Observed Ratio (OR).

Data on the stable strontium content of human vertebrae obtained in New York City, Chicago, and San Francisco are presented in table 1.

A summary of the data presented in table 1 and the Observed Ratios found at the three cities is presented in table 2. The average calcium concentration found in the ashed vertebrae was 37%. This result has been used in calculating the Sr/Ca ratios.

Discussion

The data show, as expected from the diet data, that on the average there is more stable strontium in the bone specimens obtained in the San Francisco area than those obtained in New York City, with samples from Chicago having intermediate concentrations. Although, there are relatively few samples, the general distribution of Sr/Ca ratios with age at each of the cities is similar to that found by Bryant and Loutit for human bone samples obtained in the United Kingdom (*3*).

The calculated Observed Ratios are consistently lower than was expected. Bryant and Loutit obtained a bone/diet OR of 0.25, a result which is consistent with other experiments using double tracer techniques as well as estimates made from strontium-90 measurements in human bone (*4*).

It is noteworthy, however, that despite this difference from the expected value, the OR is approximately the same for the three cities although the stable strontium intake varies by more than a factor of two.

Before the conclusion can be accepted that there is in fact more discrimination by the

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* Data from *Quarterly Summary Report, HASL–132*, January 1, 1963.

TABLE 1.—STABLE STRONTIUM IN HUMAN VERTEBRAE

Age at death (years)	New York City		Chicago		San Francisco	
	ppm[a]	µg/g Ca[b]	ppm[a]	µg/g Ca[b]	ppm[a]	µg/g Ca[b]
0-1	51	138	96	259	93	251
1-2	45	122			122	329
2-3	57	154	[c]72	[c]208		
3-4	55	149	65	176	104	281
4-5	66	178	116	313	143	386
5-6	68	184				
6-7	66	178	61	165		
7-8	76	205	73	197	85	230
9-10	89	240	70	189		
10-12	78	211	133	359	115	310
12-14	67	181			77	208
14-16	146	394	68	184	179	483
16-18	65	176	71	192		
18-20	81	219	73	197		
20-40	[c]76	[c]204	[c]113	[c]305	[c]89	[c]241
40-60	[c]114	[c]308	[c]98	[c]264	[c]105	[c]282
>60	[c]78	[c]211	[c]113	[c]304	[c]376	[c]1,014

[a] Parts per million in ash.
[b] Assuming 37 percent calcium in ash.
[c] Average of two samples.

TABLE 2.—STABLE STRONTIUM IN BONE AND DIET

City	Average mg Sr/g Ca				Average bone/diet observed ratios
	Diet	Vertebrae			
		Age < 20 years[a]	Age > 20 years[a]	Average of < 20 & > 20	
New York	1.5	0.195	0.241	0.218	0.15
Chicago	2.3	0.221	0.291	0.256	0.11
San Francisco	3.4	0.310	0.512	0.411	0.12

[a] Averaged from data in table 1.

body against strontium in favor of calcium than was previously thought, several sources of potential error in O.R. estimates must be considered.

Most of the analyses of foods as well as bone were done by emission spectroscopy. A quality control program, intercomparing samples with results obtained by neutron activation analysis and by flame photometry on all types of matrices, showed generally good agreement between methods. The estimated precision of the analyses was ± 5%. There was no evidence that bone samples were giving systematically lower results than food samples.

It is possible that the estimates of the stable strontium intake at the three cities is in error, but if this is the case it is likely that the estimate is too low rather than too high since some

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items which may contribute substantially to the annual intake of stable strontium have been excluded, e.g. tap water.

Another possible source of error is that vertebrae may not have the same strontium content as other parts of the skeleton. However, this possibility does not seem likely on the basis of the observations of Thurber, et al. (*5*) on the variability of strontium concentrations between bones in eleven cadavers.

These findings suggest that if there is an error in the calculated OR it is probably due to an inadequate sample size. More data are being obtained on the stable strontium content of foods and human bone so that the validity of this method for the estimation of strontium-calcium discrimination can be more accurately established.

Conclusion

The average Bone/Diet ratio of the stable strontium to calcium ratio was found to be about 0.13. If this number is correct, the body in fact has a considerable (7.7 to 1) preference for calcium rather than strontium. The major source of error is the small sample size.

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Radiation Exposure From Luminous Watch Dials[1]

W. Seelentag and H. Schmier[2]

The first Radiation Protection Regulation of June 24, 1960, of the Governmental Health Agency (West Germany) considers all radiation exposure of natural or artificial origin, including that from luminous paints. In the section on luminous paints incorporating radioactive substances (*1*) firmly adherent luminous paints do not require special approval if:

(a) they do not exceed a limit of 10 microcuries, except for radium, and
(b) the dose emitted from the uncovered source of radiation at a distance of 0.1 meter does not exceed 0.1 millirem per hour.

The regulation applies to both the manufacture and repair of such watch dials. Permissible "activating" materials are only relatively small amounts of radiotoxic substances, exclusive of radium. This includes promethium-147 or tritium, but not strontium–90, which has been used recently by various [non-German] firms (*2*, *3*). Strontium–90-activated dials are not admitted to free sale in German commerce.

Formerly, fluorescent materials to induce luminescence consisted mainly of so-called technical mesothorium (according to W. Minder (*4*), this meant about 70 percent mesothorium and radiothorium and about 30 percent radium). In recent years, pure radium predominated (oral communication from Minder), whereby alpha activity served as the main means for producing fluorescence, while the beta activity and accompanying gamma rays produce an unwanted side effect contributing to the much discussed radiation exposure of the wearer. Currently, efforts are being made to achieve the use of pure alpha or beta sources, such as promethium–147 and tritium, to minimize the dose of unwanted gamma rays received by the wearer.

The official limit for a radiation exposure from an uncovered timepiece is 0.1 mrem/hour

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[1] Abstracted from *Bundesgesundheitsblatt*, No. *16*: 285–8 (1961).

[2] Prof. Seelentag is Director and Dr. Schmier is Scientific Counsel with the Institute for Water, Soil and Air Hygiene, National Department of Health, Berlin-Dahlem, Germany.

TABLE 1.—RADIUM CONTENT OF LUMINOUS DIALS OF MEN'S WRIST WATCHES

Author, locality	Year observations	μg radium equivalent	
		Average value	Minimal maximal range
Brit. Med. Res. Council (7)	1956	0.2	
Glaser, Schramberg (8)	1957	0.035	(0.03 -0.042)
Ibid	1958	—	(0.045-0.100)
Joyet, Zurich	1958	0.36	(0.06 -0.81)
Ibid	1960	0.144	(0.106-4.46)
Flatby & Koren, Oslo	1959	0.19	
(According to Seelentag)	1959 (according to taxes on paint)	—	(0.006-0.165)
Seelentag & Klotz, Munich	1959	0.04	(0.008-0.095)
Berlin	1961 German makes (omitting extremes)	0.014	(0.002-0.045)
	Swiss makes (few specimens)	0.070	(0.013-0.175)
	All watches (including extremes)	0.063	(0.002-0.885)

from a distance of 10 cm. This means 0.88 rem/year, or less than one-fifth the established occupational whole-body dose. Watches that do not meet this requirement should not be permitted to be sold.

Whether the watch user receives an undesirably high or even harmful dose should be considered from three points of view:

1. According to the physical dosimetric or physical amount of activity, i.e., the effective amount of radiation.
2. Biological-medical aspects, which is concerned with harmful or potentially harmful effects, and
3. According to whether the radiation exposure is limited or general.

Judgement will depend on such questions as the consequences and possible benefits of procedures, as in X-ray diagnostic procedures wherein a certain exposure might be justified.

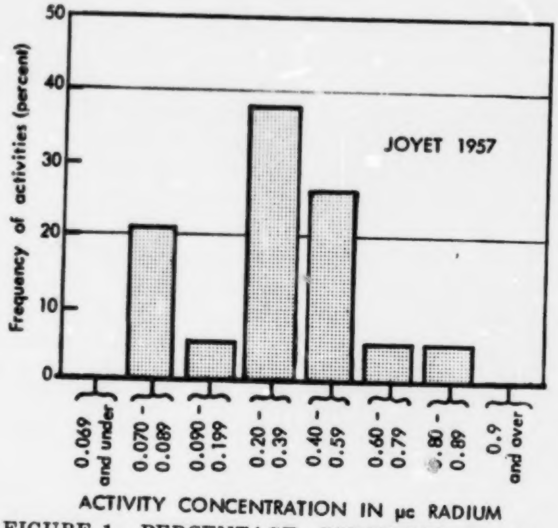

FIGURE 1.—PERCENTAGE DISTRIBUTION OF TEST WATCHES GROUPED ACCORDING TO ACTIVITIES

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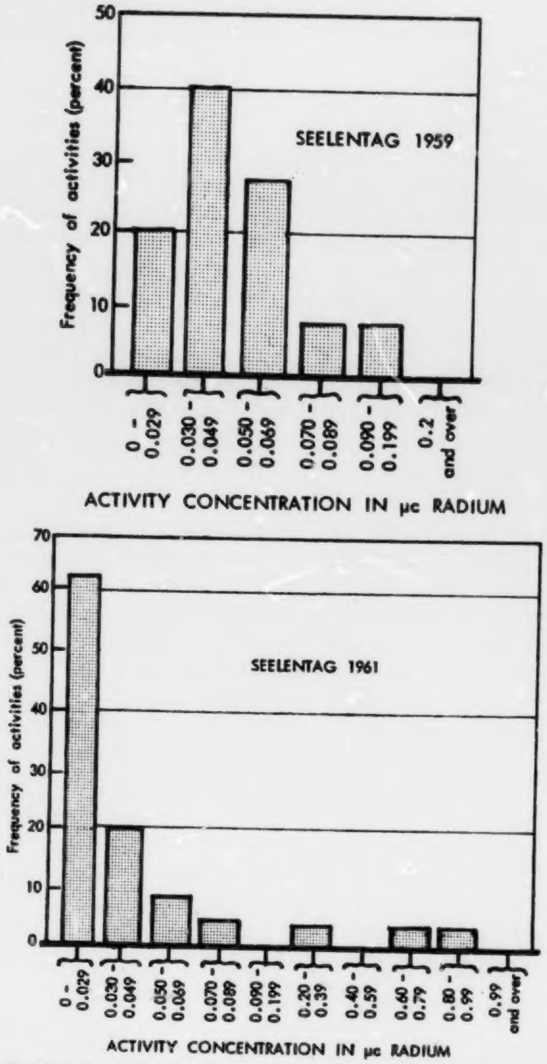

FIGURE 1.—PERCENTAGE DISTRIBUTION OF TEST WATCHES GROUPED ACCORDING TO ACTIVITIES—CONTINUED

The physical-dosimetric quantities depend primarily in the amount of radioactive substance present, and secondarily on the way the timepiece is used (as wristwatch, alarm clock) and on the time involved in its use (day and night, days only, nights only).

Literature accounts of the radium content of dials are assembled in table 1; these data are supplemented by the authors' recent findings. Figure 1 charts percentagewise the distribution of activity in watches examined, as reported by Joyet (*3*) in 1957, Seelentag and Klotz (*5*) in 1959, and our findings in 1961. It can be seen that considerable differences in activity exist among the timepieces examined. Furthermore, there was observed in Germany during the years 1958–1961 a notable tendency for the amount of activity to diminish. In watches examined in 1961, those with higher activity (in excess of 0.1 µg radium equivalent) were represented chiefly by so-called sport watches. The maximum value of 0.9 µg radium equivalent was obtained for an older model which had a luminous circle. The median values shown in table 1 were markedly affected by these relatively few watches and would have been much lower if they were omitted. Watches with ratings of about 5 µc radium, the extreme value found by Joyet, did not appear in our series.

With knowledge of the radioactivity present in the watch, the radiation exposure of the user can be calculated relatively easily. The values calculated by Seelentag and Klotz in 1959 are given in table 2. The assumption was made (for wrist watches) that the average distance from the gonads was 30 cm, and the wearing time, 24 hours daily; for alarm clocks, the assumption was a 1-meter distance and 8 hours daily exposure.

TABLE 2.—RADIATION EXPOSURE OF INDIVIDUALS FROM LUMINOUS DIALS*

(after Seelentag & Klotz, 1959)

Type of timepiece	Average radium content (µg)	Dose µr/hour	Yearly dose mr
Large alarm, at 1 meter, 8 hrs/day	0.12	0.15	0.4
Travel alarm, at 1 meter, 8 hrs/day	0.08	0.10	0.3
Ladies wrist watch, at 3 cm., 24 hrs/day	0.010	0.15	1.3
Men's wrist watch at 30 cm., 24 hrs/day	0.04	0.6	5.3
Men's wrist watch, local (forearm)		300	2600

* Calculated on basis of scattering of 50 percent for whole body-gonadal dose, and 20 percent local dose to forearm.

Exposure due to beta radiation, which occurs in time through the watch glass, was not included in the calculations, since its body penetration was a few millimeters at most; so that any noticeable effect on the whole body, the blood-forming organs, or the gonads would not be anticipated. In the last line of table 2, the local exposure to the forearm is given for wristwatches. The beta radiation to the skin need not be counted, since it would be completely absorbed by the case and mechanism.

Joyet (*3*), and Flatby and Koren (*6*) measured radiation doses in persons for whom special watches or plexiglass blocks were prepared and worn, which emitted about 100 times the normal activity. Their dosage measurements were in agreement with our calculations. Table 3 presents these dosage values; the calculated values were somewhat higher, apparently because the average distance to the gonads was somewhat greater than the assumed 30 cm. An interesting feature of the measurements of Flatby and Koren is the observation that the gonadal exposure during the 16 daylight hours was only about one-fifth of what it measured when the watch was also worn nights.

From the biological-medical point of view, we must distinguish between the radiation to the whole body (general somatic activity), to limited parts of the body surface (local somatic activity) and to the genetic substance, which involves the possibility of genetic damage. One can proceed from the radiobiological findings and knowledge of the radiation doses at which no effects have as yet been observed; from this one can calculate the so-called maximum permissible occupational radiation dose which, according to the recommendations of both the International Radiation Protection Commission and the German Radiation Protection regulations, establishes a safety factor of more than 10. These recommendations are used also in connection with the local exposure to the forearm resulting from the wearing of wristwatches.

Since we do not know the threshold level below which certain effects of radiation to the whole body and especially mutative effects may occur, we have to use as our base for the general somatic and genetic activity the so-called natural background radiation, which for millions of years has acted on man and all living things on earth. We may assume that radiation levels in the order of natural radiation and variations thereof have no greater effects than other factors that exist in our enviroment. From the point of view of genetics, however, we must take into account that modern man has been able to generate various artificial sources of radiation, introducing the danger that their sum may overstep allowable limits.

Whole-body dose can be correlated, in general, with gonadal dose. For purposes of reference for both, table 3 gives this in terms of percentage of natural radiation received by the wearer of the wrist watch over the period of a year. In the majority of cases, this amounts to 1–4 percent, but can reach more than 75 percent in the cases of watches with highest activity measured by us, and more than twice the natural radiation for the extreme values reported by Joyet. It must be repeated, however, that the dosage limitation by the radiation protection regulations alone restrict gamma radiation of watches to a maximum of 1 μc radium!

TABLE 3.—RADIATION EXPOSURE FROM WRIST WATCHES OF DIFFERENT ACTIVITIES

Author	Activity (μg radium equivalent)	Gonadal whole body dose		Local dose, forearm	
		mr/yr	Percent of natural radiation[1]	mr/yr	Percent of MPD[2]
Seelentag & Klotz, 1959	0.04	5.3	3.5	2,600	4.3
Seelentag & Schmier, 1961	0.014	1.8	1.2	850	1.4
(minimum value)	0.002	0.3	0.2	122	0.2
(maximum value)	0.885	115	77	54,000	90
Flatby & Koren	0.19	23	15	—	—
Flatby & Koren[3]	0.19	4.4	2.9	—	—
Joyet (men's watches)	0.14	9.8	6.5	—	—
Joyet (ladies' watches)	0.06	3.9	2.6	—	—
Joyet (maximum value)	4.5	310	210	270,000	450
[For comparison and correlation against other activities:					
Seelentag	1.0	130	Approx. 90	Approx. 60,000	100
Flatby, 24 hrs	1.0	120	Approx. 80		
Flatby, (days only)	1.0	23	Approx. 15		
Joyet (men's watches)	1.0	70	Approx. 50		
Joyet (ladies' watches)	1.0	65	Approx. 40		

Note: Doses of Seelentag and coworkers are calculated, and those of Flatby and Koren, as well as Joyet, measured on wearers of watches which had up to 100 times the activity of normal illuminated dials.

[1] Background radiation of 150 mr/year assumed, which compares with the ICRP maximum permissible whole body dose of 170 mr/year for the total population.

[2] MPD = Maximum permissible dose (occupational rate) for local forearm for year = 60 r = 60,000 mr.

[3] Daytime wearing only (in the row above, however, night wearing is calculated into the estimates). Watches with higher activity should not be worn nights, since apparently daytime distance from gonads is less than that at night.

Local exposure to the forearm is given in terms of maximum permissible occupational dose. It is generally in the order of 1.5–4.5 percent of this maximum permissible dose, but in the example of our "most active" time-piece it can reach nearly 100 percent if worn on a 24-hour basis. In Joyet's series, the maximum permissible dose can be exceeded by 3 or 4 times in watches of highest activity.

For estimation of genetic activity, it is not only meaningful to know what radiation levels are received by the gonads of the individual wearers of the watches, but it is more important to consider the frequency with which such watches are worn by the population as a whole, and what might be the "average probable reproductivity of the wearer"; i.e. the age distribution of the wearers. Seelentag and Klotz (*5*) calculated this so-called average genetic dose and arrived at a figure of 2 percent of natural background. At the established reduction for average activity for German watches, and also considering a reduction in numbers of such watches—fewer than 50 percent of men's wrist watches of recent manufacture have luminous dials—the average genetic dose should be less than 1 percent of natural radiation.

The radiation exposure from luminous dials of alarm clocks may be considered negligible, certainly by comparison with wrist watches.

SUMMARY

In the first Regulations for Radiation Protections, paragraph 11 contains definitions of harmful or dangerous activity concentrations for radiation from luminous dials for individuals. Recent measurements of wrist watches show a definite trend toward a reduction in such activity. In the case of German-made watches, at least, most have radium amounting to less than 0.06 and usually only about 0.02 μg. The radiation dose to wearers of such watches amounts to only a small percentage of the natural background radiation. The local dose to the skin of the forearm ranges around a few percent of the maximum permissible occupational dose. Exceptions, however, are found among watches of foreign [non-German] manufacture, especially so-called sport watches, which may give a whole body radiation exposure in the order of magnitude of natural background radiation, and local forearm dose up to the maximum permissible occupational dose or even higher. Such watches should not be worn all day, and should at least not be worn at night. Somatic manifestations, such as effects on the blood picture, or local erythema, or pigmentation of the forearm, do not occur even in the latter cases; when they occur, it is due to causes other than ionizing radiation.

Moreover, the average genetic dose from these timepieces to the population appears to be relatively insignificant, according to current estimations; it amounts to only about 1 percent of natural background radiation exposure. Nevertheless, it should be a basic rule that every artifical radiation exposure is undesirable unless—as in the use of ionizing radiation in medicine—it is justified.

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Whole Body Counting

Whole body counters are being applied where the detection of low levels of radioactivity in the human body is important. One example is the evaluation of hazards to radiation workers and the general population. These instruments are also used in human physiological and pathological investigations as well as in studies related to counter design for special purposes. Discussion and presentation of whole body counting results in previous issues of *Radiological Health Data* have been limited to medical research programs employing thallium-activated sodium iodide crystals or liquid scintillation solutions.

GEOGRAPHICAL DISTRIBUTION OF CESIUM-137 IN MAN

July 1958 through September 1962

Walter Reed Army Institute of Research

In 1955, cesium-137 was first detected in man at the Argonne National Laboratory (*1*). It emits a 0.661 Mev gamma photon, which can be quantitatively determined by a properly calibrated whole body counter. Since cesium is physiologically similar to potassium, and for the most part exists intracellularly, the cesium-137 levels are usually expressed in micromicrocuries per gram of potassium. The Walter Reed Army Institute of Research, in its program for measuring the cesium-137 levels in man, utilizes a liquid scintillation counter at Landstuhl, Germany (*2*) and at Washington, D.C. (*3*), and a thallium-activated sodium iodide crystal in a low background shield (*3*) at Washington, D.C. The analyses for cesium-137 have been carried out since 1958.

Previously published data for the period July 1958 through August 1962, together with additional data from Landstuhl, Germany, for September 1962 are summarized herein (in table 1) for the first time by principal geographical areas of residence. Although the effect of latitude on the cesium-137 burden in man is not readily apparent from the data, some geographical variation can be noted. Residents of Europe, including West Germany, as shown in figure 1, have higher cesium-137 body burdens on the average than residents in the United States and the Far East.

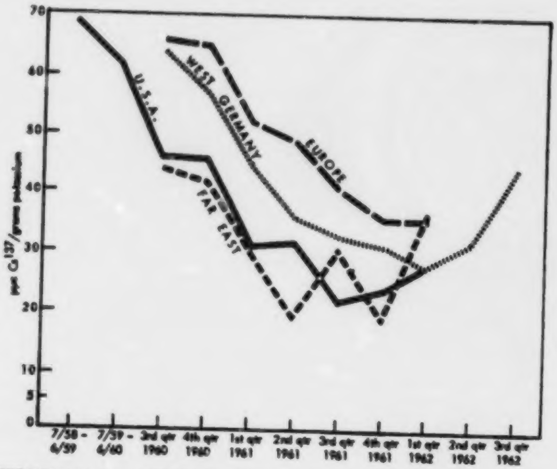

FIGURE 1.—CESIUM-137 BODY BURDENS IN RESIDENTS OF SELECTED AREAS

Figure 1 also shows the effect of the cessation of nuclear weapons testing in the decreasing cesium-137 body burden from 1959 into the first quarter of 1962. Also, the resumption of nuclear weapons testing in 1961 is reflected by the increasing cesium-137 body burden in residents of West Germany in the second and third quarters of 1962. The apparent "spiking" of the cesium-137 body burdens in residents of the far east has not been analyzed for statistical significance.

The maximum value tabulated and plotted, 69 $\mu\mu c$ Cs^{137}/gram potassium in the USA for fiscal year 1959, is computed to be 0.32% of the maximum permissible whole body burden of 3 μc* of cesium-137 for the general population (*4*).

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* MPBB for general population = 1/10 MPBB of 30 μc Cesium-137 (occupational exposure).

TABLE 1.—CESIUM-137 IN MAN, JULY 1958–SEPTEMBER 1962

($\mu\mu c$/gram potassium)

Residence	July 1958 through June 1959	July 1959 through June 1960	Third quarter 1960	Fourth quarter 1960	First quarter 1961	Second quarter 1961	Third quarter 1961	Fourth quarter 1961	First quarter 1962	Second quarter 1962	Third quarter 1962
U. S. A.	69 [a] (906)	62 (744)	46 (147)	46 (164)	31 (170)	32 (75)	22 (61)	24 (80)	28 (104)	[b]	
West Germany			64 (982)	57 (1299)	45 (488)	36 (610)	33 (1305)	31 (1634)	28 (1181)	32 (837)	45 (834)
Europe			66 (36)	65 (40)	52 (32)	49 (11)	41 (5)	36 (14)	36 (7)		
Far East			44 (27)	42 (38)	30 (28)	19 (3)	31 (2)	19 (9)	37 (3)		
Near East			33 (1)	62 (2)	49 (2)						
Central America			58 (1)	59 (2)	28 (1)			24 (1)			
Caribbean				58 (2)	37 (4)	20 (3)					
Pacific Islands				43 (5)	26 (1)		20 (4)				
Canada				55 (1)				26 (2)			
Asia			32 (1)								
Africa			65 (1)		35 (1)						
Greenland			45 (1)								
Australia						36 (1)					
Antarctica					50 (1)						

[a] Numbers in parentheses refer to number of analyses.
[b] Blank indicates no data.

Survey of X-Ray Facilities in Los Angeles

Charles L. Senn,[1] Jack C. Rogers,[2] Joseph Karbus,[3] Raymond A. Miller,[4]
Bruce Ault,[4] and Gerhardt Terhoeven[5]
Los Angeles City Health Department[6]

Since 1947, the Los Angeles City Health Department has had legal responsibility for radiological health control as a part of its overall concern with "toxic chemicals." The applicable ordinance subjects to Health Department control any substance which emits ionizing radiation to a degree that may adversely affect the health of exposed persons. The Department's survey in 1956 of shoe flouroscopy units revealed exposures of children to grossly excessive doses of ionizing radiation. The resulting publicity led to the adoption of corrective measures and to steps toward amending the above ordinance to include authority to regulate and control machines or devices that generate ionizing radiations.

In keeping with its general policy of developing ordinances and rules through the cooperation of advisory committees, the Department organized a radiological health advisory committee to assist the Division of Occupational Health in developing necessary criteria for establishing a radiation control program. The County Medical Society, the Southern California Dental Association, the Los Angeles Radiological Society, several research depart-

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ments from each of four universities, manufacturers and users of radioactive equipment and materials, companies involved in the X-ray equipment and radiation instrumentation field, and other experts served on this radiological health advisory committee. In addition to identifying the areas of concern in radiological health control, it was necessary to determine the extent to which licensed practitioners should be governed and the need for amendment of existing ordinances to cover both materials and machines. The concept agreed upon was that the rules should, among other things, prohibit *unintentional* ionizing radiation. Detailed rules and regulations were adopted, providing for the development of programs and for implementing the inspection work associated with their enforcement.

As one phase of its radiation control program, in July 1962 the Health Department completed initial inspections of approximately 2,700 radiation facilities in the city of Los Angeles. These facilities are divided basically into three major categories: medical, dental, and industrial. The results of the inspections conducted in the medical and dental fields, which accounted for approximately 94 percent of the combined total of all radiation facilities in Los Angeles, are discussed and presented in figures 1 and 2.

SURVEY FINDINGS

Medical X-Ray Facilities

A total of 1,398 medical facilities was inspected, representing 52 percent of all radiation installations in the city. This included approximately 2,000 medical X-ray machines of all types—an average of slightly below 1.5 machines per facility. All medical specialties and installations were covered, including radiologists, general practitioners, chiropractors, veterinarians, podiatrists, and hospitals.

The following factors were considered in the inspection and evaluation of the facilities: (1) size of the primary (useful) beam delivered to the patient; (2) filtration; (3) direction of the primary beam; (4) operator protection; (5) occupancy of adjacent areas; (6) assessment of total exposure to individuals and/or areas.

1. *Beam Size or Collimation.*—Evaluation was guided by the principle that the useful beam should be no larger than necessary for the desired diagnostic or therapeutic purpose. Generally, this means that the beam size should not exceed the size of the film used in a particular X-ray examination. Film ranged in size from 8 x 10 inches to 14 x 36 inches. With a circular cone, a 14 x 17-inch chest film would require a 22-inch diameter beam. Since many X-ray operators have difficulty in centering the beam on the film, it was considered reasonable to make an allowance in beam size of an additional inch on each side. Thus, for a 14 x 17-inch chest film, the beam could be as large as 24 inches in diameter.

Excessively large beams were found in 41 percent of all chest radiography units, 20 percent of trunk radiography units, and 19 percent of units for extremity exposures. Particular importance was attached to trunk exposures, since the reproductive area was frequently exposed, even though not of diagnostic interest. Fewer than 5 percent of the total medical facilities had available and used appropriate gonadal shielding.

Recommendations.—Facilities with excessive beam sizes were given written notice or assistance to correct deficiencies. This generally involved getting a new device (cone) or proper application of available cones. Fewer than 10 percent of all X-ray machines were using new adjustable collimating devices which permit accurate setting of beam size relative to film size and target-to-film distance.

The following future actions are planned:

a. Mark all collimators according to use and application, and educate operators in proper cone use and selection.
b. Require purchase of and application of proper local gonadal shielding.
c. Recommend use of rectangular shutter collimators wherever possible, particularly in new installations.

2. *Filtration.*—Evaluation was based on the standard requirement of 1.5 mm of aluminum equivalent for X-ray machines operating under 70 kvp and 2 to 2.5 mm for units operating at 70 kvp and above (*1*). Approximately 45 percent of medical radiographic facilities were found to have inadequate filtration. Some of the older units with no added filtration had an inherent filtration of approximately 0.5 mm aluminum equivalent. Such machines were

often required to have an additional 2 mm aluminum provided. The range of kilovoltages used in a typical medical facility for the various radiographic techniques involved suggests that not one but two standard filter thicknesses should be applied for the low and high kilovoltage ranges used.

Recommended future activities on filtrations.—

a. Advise selective application of filters in medical offices. A total of 1.5 mm total should be provided in the beam path for techniques below 70 kvp and an additional 1 mm or 2.5 mm total should be provided for over 70 kvp techniques.
b. Determine field method of evaluation of filtration characteristics of X-ray units.
c. Furnish a medical X-ray bulletin.

3. *Operator Protection.*—Eleven percent of all installations were found to have inadequate protection for the X-ray operator. A "suitable protective barrier" was interpreted to mean a built-in booth, a separate room or area, a fixed or portable lead shield, or a means of locating the control button outside of the X-ray room behind a wall of at least two-sided standard plaster. An additional criterion was a provision for the operator to be able to view the patient so that he would not have to leave his protection during exposure.

Tests of a limited number of operations revealed that some operators actually received less than 10 mr/week where an adequate protective barrier did not exist. This was due to limited utilization of the machine; 62 percent of all medical facilities had workloads averaging less than 10 milliampere-minutes per week.

4. *Exposure Record.*—Twenty-one percent of all facilities had employed a personnel monitoring service within the last four years. The majority of these facilities had records indicating that exposures received by X-ray operators were consistently below the permissible average weekly dose of 10 mr (*1*). In practically every case, these facilities had a suitable protective barrier for the operator. An occasional high exposure (over 100 mr per week) could often be attributed to misplacement of the film badge in the X-ray room or to actual exposures resulting from repeated holding of patients and therefore direct beam exposure.

Recommended future activities on exposure record.—In all installations where operator protection is found inadequate, routine pocket chamber exposure tests will be made to determine exposure doses received and thereby to evaluate the significance of hazard.

5. *Exposure and Occupancy in Adjacent Areas.*—In a limited number of cases, field tests were conducted where a potential exposure problem was suspected in an adjacent uncontrolled room or area. Measurements in practically every case indicated that total weekly exposure in the uncontrolled area fell below 10 mr. Where high workloads existed, the rooms generally had heavy lead shielding.

Veterinary X-Ray Usage Facilties

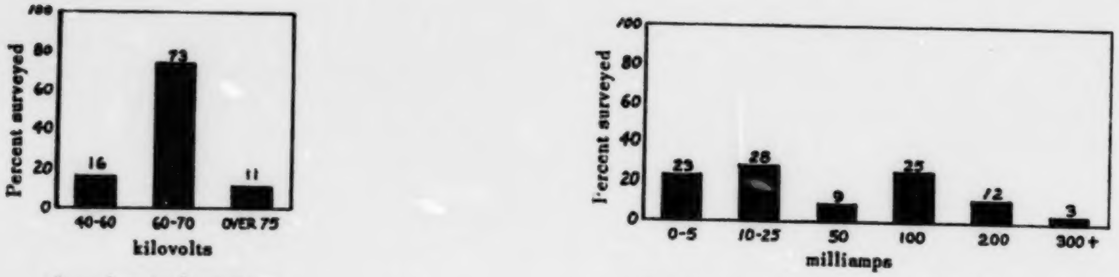
Inspection of veterinary installations indicated that most units were handled acceptably. Collimation could usually be accomplished by adapting some of the dental collimators used in the program. Emphasis was placed on the use of lead aprons and gloves for the operator who must of necessity hold the animal for radiography.

Chiropractic X-Ray Facilities

The chiropractic profession in California is licensed in the healing arts and is considered qualified to use X-ray for diagnostic, radiographic, and fluoroscopic work. A major portion of the equipment in use by this group was over 10 years old and generally not up to standards with respect to filtration and collimation. The largest problem was lower spinal X-ray, which immediately involves gonadal exposure. By working with members of this profession experienced in roentgenology, it was possible to promote better standards of protection to both the patient and the operator.

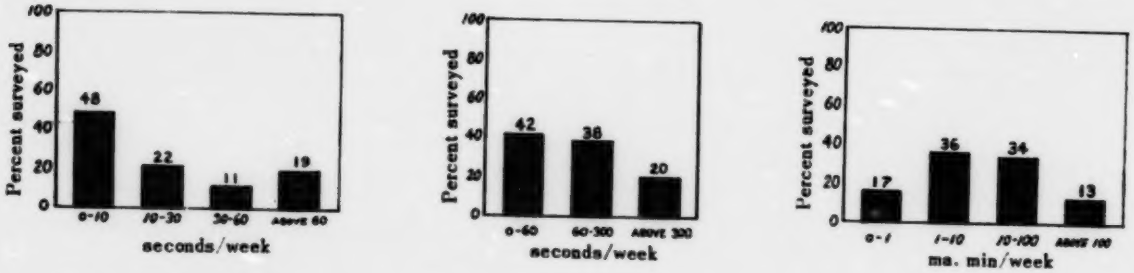
Fluoroscopic Units

It was noted that many general practitioners had fluoroscopic units, most of them of the upright cabinet type and over 10 years old. Filtration was below standard in most instances. Many of the shutter stops were misadjusted, allowing emergence of the primary beam beyond the edges of the leaded glass screen. The use of fluoroscopy was, however, found to be diminishing to an occasional spot check of short duration, and many had ceased using it entirely. Almost all units used by radiologists were well above minimum requirements (*1*).



1a.-- Average kv usage

1b.--Ma usage



1c.--Workload (Radiography)

1d.--Workload (Fluoroscopy)

1e.--Workload

FIGURE 1.—SUMMARY OF SAMPLING OF MEDICAL INSTALLATIONS INSPECTED

Photofluorographic Units

A survey of health department X-ray facilities revealed that many photofluorographic units were using blue flourescent screens with a blue sensitive film. Information from the U.S. Public Health Service, confirmed by an equipment manufacturer, had indicated that a green fluorescent screen would result in a 50–60 percent reduction in whole body radiation. Correction of this condition accomplished a substantial reduction in unnecesary ionizing radiation.

Installation Usage and Workload

Figure 1a–e summarizes the usage and workload of medical installations inspected.

Dental X-Ray Facilities

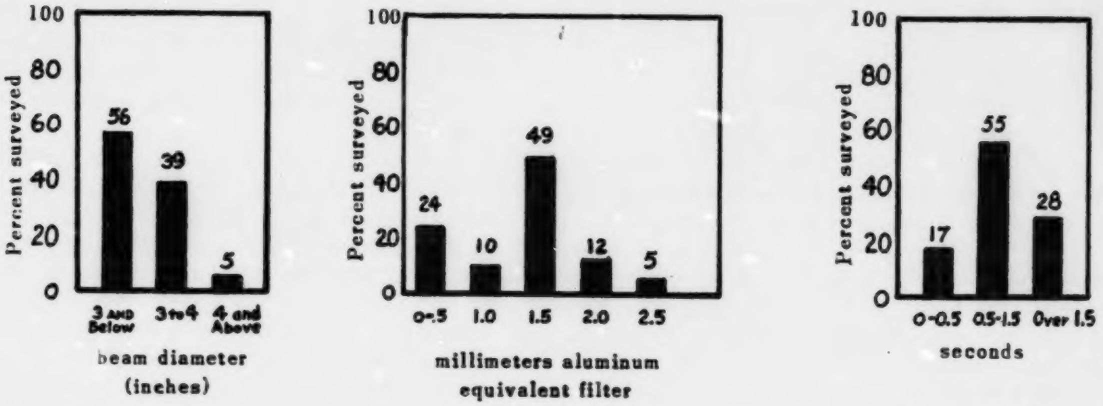
The total number of dental facilities inspected was 1,119, with 1,455 X-ray machines, or an average of 1.3 machines per facility. The program included inspection, assessment and correction, where necessary to reduce unnecessary exposure, based on factors corresponding to those evaluated in the medical program.

1. *Collimation.*—Figure 2a shows the findings with regard to beam size of the dental X-ray units surveyed. Forty-three percent of all units were corrected on the spot for excessive beam size by insertion of a lead collimator which reduced beam diameter to the standard requirement of 2.75 inches (*1*). Twenty-seven percent of all units inspected were found to have an average beam diameter of 3.5 inches, resulting in an exposure area 40 percent larger than needed. Six percent had an average beam diameter of 4.5 inches, resulting in a 62 percent larger exposure area of the face than necessary. Following all corrections, an average area reduction of 27 percent was achieved.

Future activities proposed are:

a. Installation of collimators where necessary.
b. Educational programs to assure their proper use.
c. Continued effort to insure that new equipment is satisfactorily collimated.

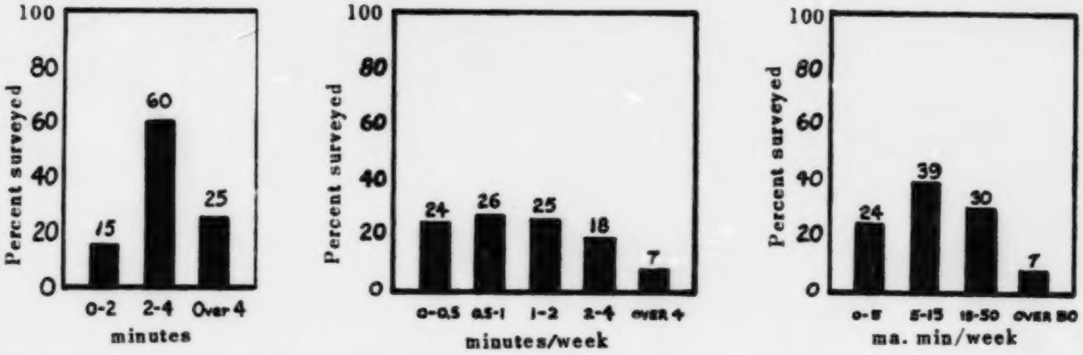
2. *Filtration.*—The distribution of filter thicknesses in mm of aluminum equivalent is presented graphically in figure 2b. Forty-one



2a.--Collimation

2b.--Filtration

2c.--Exposure time



2d.--Development time at room temperature

2e.--Workload

2f.--Workload

FIGURE 2.—SUMMARY OF SAMPLING OF DENTAL INSTALLATIONS INSPECTED

percent of all dental units had inadequate filtration, based on standards of 1.5 mm aluminum equivalent for 65 kvp units and 2.5 mm for 90 kvp units. Correction was made on the spot by the addition of necessary filtration where needed. The average amount of filtration added to the machines corrected was approximately 0.9 mm of aluminum equivalent. The great majority of corrections were made to the 65 kvp machines found to have only 0.5 mm inherent aluminum equivalent and no added filtration. In these cases, the addition of 1 mm aluminum brought about a reduction of 50 percent in total radiation exposure.

Further activities will be directed to:

a. Determination of a suitable field method to evaluate inherent filtration characteristics of X-ray units.

b. Installation of filters in dental machines that did not previously receive needed filters.

3. *Operator Protection.*—Protection afforded by either a fixed or portable lead shield or by a standard plaster wall was observed in 36 percent of all facilities inspected. Where unnecessary operator exposure was noted, recommendations for change in position were made.

During subsequent visits, operator and area exposure determinations will be made to evaluate if exposure is excessive and/or if film badging is needed.

4. *Exposure and Development Time.*—Of all units inspected, 17 percent had exposure times averaging less than 0.5 seconds and 28 percent more had exposure times averaging 1.5 seconds, as shown graphically in figure 2c.

The first group generally used 90 kvp machines or high speed films or both; in the long-exposure group, many had average exposure times of 3 seconds or longer. The middle group, comprising 55 percent of the total, used predominately 65 kvp machines with mechanical timers and medium speed commercial film. The one-second average exposure of this group is considered reasonable. The use of high speed film would reduce exposure significantly, but the difference in radiographic image appears to present a fundamental objection to dentists who are accustomed to medium speed film.

The control of development factors such as solution quality was in most cases entrusted to a commercial supplier on a monthly basis. As shown in figure 2d, only 25 percent reported a development time of 4 minutes or more at room temperature. The other two groups, representing 75 percent of all facilities, are considered to be underdeveloping; in other words, they were overexposing to produce equivalent film density.

In continuance of the program it is proposed to:

a. Evaluate mechanical timers for accuracy.

b. Increase educational efforts to convince dentists of the value of proper darkroom procedures and equipment to reduce exposure times, including the use of faster film.

5. *Exposure Records.*—A very small percentage of facilities inspected could produce evidence of any cumulative radiation surveillance such as a film badge service. During the survey, limited exposure tests were made, revealing varying degrees of exposure. The requirement for a film badge exists if 25 percent of the MPD (100 mr/wk average) is exceeded.

Future plans include dose studies of personnel and areas, employing pocket chambers of the Division.

6. *Workload.*—The shielding requirement standards of Handbook 76 (*1*) establish a workload figure of 800 ma-minutes for a busy dental installation. Only one facility in the City of Los Angeles approached this workload. Figures 2e and 2f show the distribution of workload in minutes per week and milliamp minutes per week, respectively. Approximately 60 percent of all facilities had a weekly workload below 15 ma-minutes, and only 7 percent exceed 50 ma-minutes per week.

Acknowledgements

The authors acknowledge the services and assistance of: Norman Hume, Director, Los Angeles Bureau of Sanitation, Department of Public Works and his staff; the Industrial Hygienist and the staff of the City's Division of Occupational Health; the Division of Radiological Health, U.S. Public Health Service, and Dr. Clifford E. Nelson of that Division in particular, for his valuable guidance and counsel.

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(*1*) National Committee on Radiation Protection and Measurements: *Medical X-Ray Protection up to Three Million Volts, National Bureau of Standards Handbook 76*, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (February 9, 1961), price 25 cents.

(*2*) National Committee on Radiation Protection and Measurements: *Permissible Dose From External Sources of Ionizing Radiation, National Bureau of Standards Handbook 59*, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (September 24, 1954), price 35 cents.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

BETTIS ATOMIC POWER LABORATORY

Westinghouse Electric Corporation, Pittsburgh, Pennsylvania
Last Half of 1961 and First Half of 1962

The Bettis Atomic Power Laboratory (BAPL), operated for the Atomic Energy Commission by Westinghouse Electric Corporation, was established in 1949. Since that time BAPL has been engaged in research and development work related to naval atomic propulsion systems and the central station atomic power reactor at Shippingport, Pennsylvania.

Liquid Radioactive Waste Disposal

The liquid effluent from the Laboratory is sampled continually, and a composite sample is collected and analyzed weekly. This effluent includes the discharge from the Laboratory storm drainage system so that it may include some activity from fallout. The average concentrations of gross radioactivity and strontium–90 are presented in table 1.

TABLE 1.—RADIOACTIVITY IN LIQUID WASTES

[Concentrations in μμc/liter]

Type of activity	Third quarter 1961	Fourth quarter 1961	Average-calendar year 1961	First half 1962
Gross activity[a]	710	310	510	240
Strontium-90	2.1	1.2	1.3	[b]0.5

[a] The environmental MPC for gross radioactivity in water is 2,000μμc/liter if Sr^{90}, I^{129}, Pb^{210}, Po^{210}, Ra^{223}, Ra^{226}, Ra^{228}, Pa^{231}, and Th-nat are not present. "Not present" implies the concentration of the nuclide is small compared with its appropriate MPC. According to recent FRC recommendations, a group of nuclides may be considered not present if the ratio of each nuclide to its appropriate MPC is equal to or less than 1/10 and if the sum of these ratios for the group in question is equal to or less than ¼.
[b] First quarter only; second quarter analysis not yet available.

Beta-Gamma Background Levels

Beta-gamma background levels are continuously monitored and recorded at a monitoring station located inside the western boundary of the laboratory property, as shown in figure 1. Averages for 1961 and the first half of 1962, 0.018 and 0.021 millirads per hour respectively, may be compared with the 0.01 to 0.04 mr/hr range measured throughout the United States by the Radition Surveillance Network, Public Health Service, during 1961 and 1962.

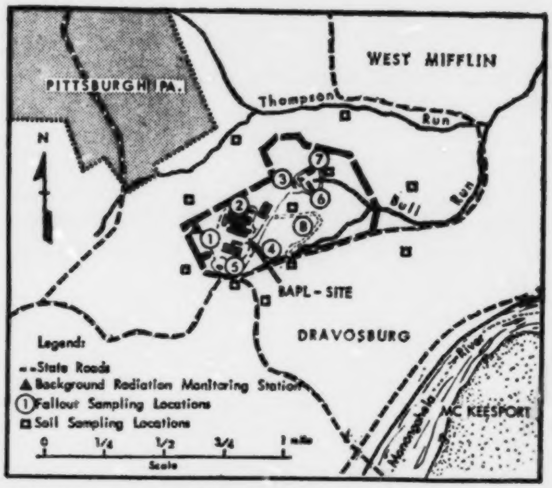

FIGURE 1.—BETTIS ATOMIC POWER LABORATORY SAMPLING STATIONS

Fallout

Monthly fallout samples are collected at the eight stations shown in figure 1. Due to the locations of the stations, the measured activity may include both fallout from the atmosphere and activity resuspended because of the movement of vehicles and construction work. The results presented in table 2 reveal no substantial differences between upwind and downwind fallout rates, but the effect to weapons testing in late 1961 becomes apparent in the fourth quarter data.

TABLE 2.—AVERAGE BETA ACTIVITY IN FALLOUT

(Deposition rates in mc/mi²/mo)

Station (See figure 1)	Third quarter 1961	Fourth quarter 1961	First 5 months 1962[1]
Upwind	13	183	239
Downwind	16	204	273

[1] June 1962 results not available.

Soil Sampling

Soil samples are collected at 11 sampling locations as shown in figure 1 during the second and fourth quarters each year. The fourth quarter 1961 average concentrations in soil based on the eleven samples were 84 μμc α/g and 43 μμc β-γ/g. Soil samples collected during the first half of 1962 had average concentrations of 55 μμc α/g and 35 μμc β-γ/g.

Previous coverage in *Radiological Health Data*:

Period	Issue
1959 and first quarter 1960	*November 1960*
Second quarter 1960	*January 1961*
Third and fourth quarters 1960	*October 1961*
First and second quarters 1961	*April 1962*

Reported Nuclear Detonations

March 1963

Only one nuclear detonation was announced by the Atomic Energy Commission during the month of March 1963. Arbitrarily referenced by *Radiological Health Data* as test number 101, this test of low yield range was conducted underground at the Nevada Test Site. (Low yield range has been announced as being less than 20 kilotons yield.)

RADIOLOGICAL HEALTH DATA

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

SECTION I.—AIR AND FALLOUT

Fission Product Beta Activity in Airborne Particulates and Precipitation

Quick and sensitive detection of fission product activity fluctuation in the environment is possible through a program of continuous surveillance of gross beta activity in air and precipitation. The information obtained through such surveillance does not by itself permit evaluation of biological effects due to fallout, but it does form the basis of an alerting system and can be used as a rough guide to when and where more extensive monitoring of radioactivity in food, milk, and water is desirable.

January 1963 gross beta concentrations are presented here in reports from the Radiation Surveillance Network, Canadian Radioactive Fallout Study Program, and the Mexican Radioactive Fallout Program. Because of differences in equipment and techniques, the results from one network are not directly comparable with those of another. However, some intercalibration factors have been determined in a study conducted by Lockhart and Patterson of the U. S. Naval Research Laboratory (*1*, *2*). An application of the results of this study is presented in figure 3, in which the January gross beta in air data from Canada and the U. S. were combined in one contour map. To adjust to a common baseline, the U. S. data were multiplied by a factor of 1.54, the U. S.-Canadian intercalibration factor suggested by the NRL study.

REFERENCES

(*1*) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: *Intercalibration of Some Systems Employed in Monitoring Fission Products in the Atmosphere, NRL Report 5850*, Washington, D.C. (November 13, 1962).

(*2*) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: Intercalibration of Some Air Monitoring Systems, *Radiological Health Data*, *3*:466-70, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (December 1962).

RADIATION SURVEILLANCE NETWORK

January 1963

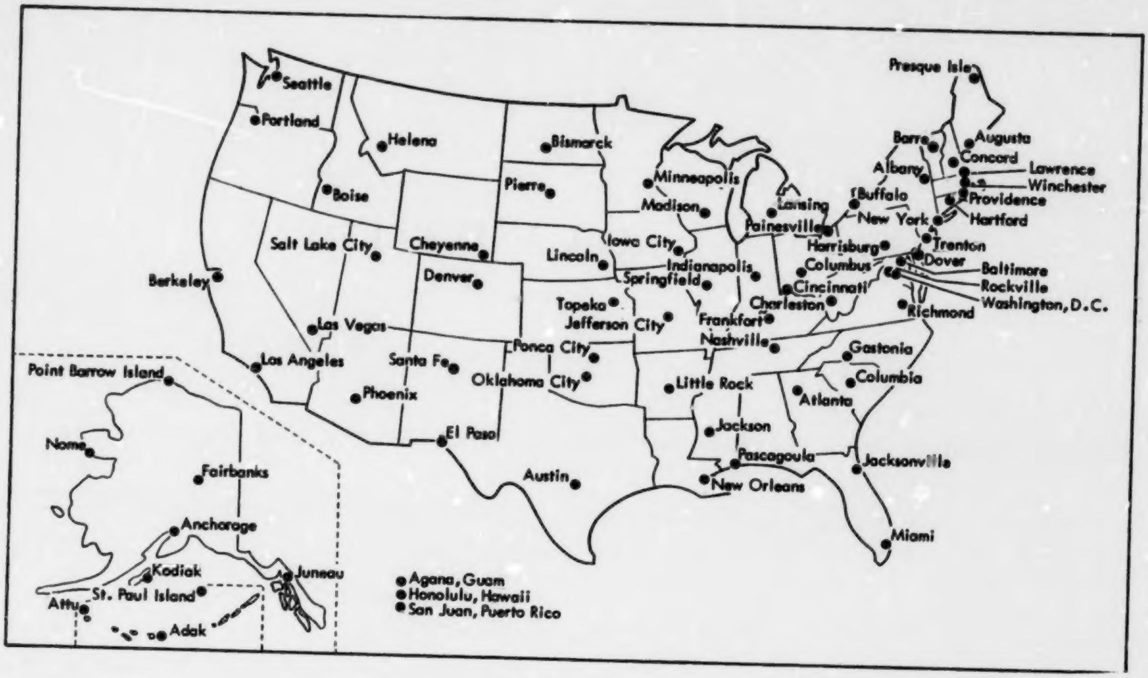
Division of Radiological Health,
Public Health Service

The Radiation Surveillance Network (RSN) comprises 72 sampling stations distributed among the fifty States, Guam, and Puerto Rico (see figure 1). These stations are manned predominantly by State health department personnel.

Air

Daily 24-hour air samples are collected by a high-volume air sampler with a 4-inch diameter carbon-loaded cellulose dust filter. Field estimates of the gross beta activity of airborne particulates are derived by comparing portable survey meter readings of these filters with readings taken from a Sr^{90}–^{90}Y known activity source. This determination is usually made about 5 hours after collection to eliminate interference from naturally occurring radon daughters. The Network's station operators contribute to a daily national report by telephoning their field estimates to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C.

The filters are then forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, for a more refined measurement using a thin-window gas-flow proportional counter. Each filter is counted at least 3 days after the end of the sampling period and re-counted 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. The two counts, separated by a 7-day


Seattle
Portland
Helena
Bismarck
Presque Isle
Barre
Augusta
Concord
Lawrence
Winchester
Albany
Providence
Hartford
Minneapolis
Pierre
Boise
Madison
Lansing
Buffalo
Painesville
New York
Salt Lake City
Cheyenne
Iowa City
Lincoln
Harrisburg
Trenton
Dover
Baltimore
Rockville
Washington, D.C.
Indianapolis
Columbus
Cincinnati
Springfield
Berkeley
Denver
Topeka
Jefferson City
Charleston
Frankfort
Richmond
Las Vegas
Ponca City
Nashville
Gastonia
Los Angeles
Santa Fe
Oklahoma City
Columbia
Point Barrow Island
Phoenix
Little Rock
Atlanta
Nome
Jackson
El Paso
Fairbanks
Pascagoula
Jacksonville
Austin
New Orleans
Anchorage
Miami
Kodiak
Juneau
Agana, Guam
Honolulu, Hawaii
San Juan, Puerto Rico
St. Paul Island
Attu
Adak

interval, are used to estimate the age of fission products and to extrapolate the activity to the time of collection. The extrapolation is performed by using the Way-Wigner formula ($AT^{1.2}$ = constant).* The daily concentrations and estimated age are reported by the PHS in a monthly RSN report (*1*).

The average fission-product beta concentrations in surface air during January 1963, as determined by laboratory analysis and extrapolated to the time of collection, are given in table 1.

In order to compare these data with the gross beta reported by Canada, an adjustment is required. The relationship given by Lockhart and Patterson[1] is

$$\frac{\text{PHS}}{\text{Canada}} = 0.65 \pm 0.048 \text{ (one standard deviation)}$$

which may be written:

$$1.54 \times \text{PHS} \pm 7.4 \text{ percent} = \text{Canada}$$

Because of the higher filter efficiency and lower self-absorption in the Canadian system compared with RSN,[1] it was considered more appropriate to adjust the RSN values upward to correspond with Canada rather than to adjust the Canadian data downward.

The Canadian air data and the adjusted RSN data rendered the concentration contour map in figure 3, which includes most of the North American continent.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis using funnels with collection areas of 0.4 m^2. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory to be counted by the same method used for analyzing the air samples, including extrapolation to the time of collection. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall) the volume of precipitation is reported, but no analysis is made. January 1963 averages of gross beta activity in precipitation, expressed in micromicrocuries per liter ($\mu\mu c$/liter) and millimicrocuries per square meter ($m\mu c/m^2$), are presented in table 2.

---

* In this expression, A is the activity and T is the time after fission product formation.

[1] See references (*1*) and (*2*) on page 225

TABLE 1.—GROSS BETA ACTIVITY OF PARTICULATES IN AIR, RSN, JANUARY 1963

[Concentrations in $\mu\mu c/m^3$]

Station location		Number of samples	Maximum	Minimum	Average[a]
Alaska:	Adak	29	9.5	<0.10	3.3
	Anchorage	30	14	<0.10	3.9
	Attu	31	31	<0.10	4.8
	Fairbanks	23	11	0.53	4.2
	Juneau	24	16	<0.10	3.8
	Kodiak	17	26	<0.10	6.4
	Nome	26	6.7	<0.10	2.8
	Point Barrow Island	23	7.9	1.3	4.5
	St. Paul Island	14	9.1	0.45	4.7
Ariz:	Phoenix	29	25	5.3	13
Ark:	Little Rock	28	15	1.7	9.3
Calif:	Berkeley	30	22	0.53	10
	Los Angeles	21	23	7.5	15
Colo:	Denver	29	21	6.3	10
Conn:	Hartford	30	11	0.56	5.9
Del:	Dover	22	19	3.5	8.8
D.C:	Washington	31	14	1.2	5.7
Fla:	Jacksonville	29	20	4.1	11
	Miami	30	20	1.6	8.5
Ga:	Atlanta	31	10	0.19	5.5
Guam:	Agana	—[b]	—	—	—
Hawaii:	Honolulu	30	11	1.7	5.1
Idaho:	Boise	30	20	3.1	9.0
Ill:	Springfield	30	9.4	1.4	5.6
Ind:	Indianapolis	29	11	0.57	6.0
Iowa:	Iowa City	28	8.4	0.99	4.5
Kans:	Topeka	28	11	1.7	6.5
Ky:	Frankfort	29	24	2.7	11
La:	New Orleans	29	16	0.59	7.6
Maine:	Augusta	31	12	1.8	6.3
	Presque Isle	19	8.2	1.3	4.4
Md:	Baltimore	22	12	0.45	5.4
	Rockville	14	12	3.0	7.3
Mass:	Lawrence	29	12	1.5	6.4
	Winchester	28	20	4.3	10
Mich:	Lansing	31	12	2.5	7.9
Minn:	Minneapolis	29	9.1	1.6	6.2
Miss:	Jackson	29	11	1.2	9.2
	Pascagoula	21	18	2.0	9.0
Mo:	Jefferson City	30	12	1.2	6.2
Mont:	Helena	30	15	3.6	8.8
Nebr:	Lincoln	19	13	1.3	5.9
Nev:	Las Vegas	28	35	5.6	17
N.H:	Concord	20	17	4.7	9.6
N.J:	Trenton	31	13	0.31	[illegible].3
N. Mex:	Santa Fe	27	16	5.3	8.6
N.Y:	Albany	28	12	0.72	5.5
	Buffalo	29	11	1.3	7.4
	New York	15	7.7	2.1	5.3
N.C:	Gastonia	30	27	1.3	9.9
N. Dak:	Bismarck	30	13	3.3	7.9
Ohio:	Cincinnati	21	11	1.3	5.7
	Columbus	29	12	1.1	7.0
	Painesville	30	16	1.4	7.7
Okla:	Oklahoma City	30	12	2.7	7.0
	Ponca City	30	6.2	1.4	3.8
Ore:	Portland	27	29	1.2	11
Pa:	Harrisburg	21	10	0.32	5.5
P.R:	San Juan	22	5.6	1.1	3.1
R.I:	Providence	30	13	0.91	6.7
S.C:	Columbia	27	13	0.82	6.6
S. Dak:	Pierre	29	9.7	2.8	6.0
Tenn:	Nashville	28	16	2.1	6.7
Tex:	Austin	31	16	1.9	8.7
	El Paso	31	17	2.8	8.0
Utah:	Salt Lake City	31	18	3.8	10
Vt:	Barre	31	15	2.0	8.2
Va:	Richmond	30	11	2.1	5.5
Wash:	Seattle	30	16	0.53	7.1
W. Va:	Charleston	22	13	2.1	7.2
Wisc:	Madison	31	13	2.2	7.0
Wyo:	Cheyenne	27	20	2.9	7.8
Network average					7.2

[a] Weighted average obtained by summing the products of individual sampling times and the corresponding activities, and dividing by the summation of the individual sampling times.

[b] Dash indicates no sample received.

TABLE 2.—GROSS BETA ACTIVITY IN PRECIPITATION, RSN, JANUARY 1963

Station location		Average concentration ($\mu\mu c$/liter)	Total deposition ($m\mu c/m^2$)
Alaska:	Adak	*	*
	Anchorage	1,700	32
	Attu	*	*
	Fairbanks	2,300	100
	Juneau	1,500	98
	Kodiak	*	*
	Nome	*	*
	Point Barrow Island	*	*
	St. Paul Island	*	*
Ariz:	Phoenix	*	*
Ark:	Little Rock	3,500	64
Calif:	Berkeley	840	79
	Los Angeles	2,200	3.8
Colo:	Denver	*	*
Conn:	Hartford	2,400	120
Del:	Dover	*	*
D.C:	Washington	2,000	96
Fla:	Jacksonville	1,400	94
	Miami	3,200	27
Ga:	Atlanta	*	*
Guam:	Agana	*	*
Hawaii:	Honolulu	*	*
Idaho:	Boise	2,700	9.2
Ill:	Springfield	3,800	7.5
Ind:	Indianapolis	2,000	45
Iowa:	Iowa City	*	22
Kans:	Topeka	*	*
Ky:	Frankfort	4,800	89
La:	New Orleans	1,300	180
Maine:	Augusta	1,300	120
	Presque Isle	*	*
Md:	Baltimore	3,100	2.4
	Rockville	*	*
Mass:	Lawrence	2,400	120
	Winchester	1,900	140
Mich:	Lansing	*	*
Minn:	Minneapolis	2,600	12
Miss:	Jackson	1,900	78
	Pascagoula	*	*
Mo:	Jefferson City	2,000	14
Mont:	Helena	2,600	22
Nebr:	Lincoln	8,000	28
Nev:	Las Vegas	*	*
N.H:	Concord	*	*
N.J:	Trenton	3,400	13
N. Mex:	Santa Fe	5,600	57
N.Y:	Albany	520	9.5
	Buffalo	510	10
	New York	*	*
N.C:	Gastonia	670	56
N. Dak:	Bismarck	3,600	15
Ohio:	Cincinnati	*	*
	Columbus	2,200	77
	Painesville	9,700	220
Okla:	Oklahoma City	6,200	40
	Ponca City	1,100	25
Ore:	Portland	3,600	76
Pa:	Harrisburg	*	*
P.R:	San Juan	440	120
R.I:	Providence	1,700	190
S.C:	Columbia	970	150
S. Dak:	Pierre	*	*
Tenn:	Nashville	7,400	12
Tex:	Austin	3,400	36
	El Paso	11,000	24
Utah:	Salt Lake City	5,900	100
Vt:	Barre	2,200	170
Va:	Richmond	1,700	66
Wash:	Seattle	2,700	68
W. Va:	Charleston	2,600	43
Wisc:	Madison	760	17
Wyo:	Cheyenne	1,700	8.6

* Indicates no evaporated sample received.

REFERENCE

(1) Radiation Surveillance Network: *Monthly Tabulation of Findings*, Division of Radiological Health, Public Health Service, Washington 25, D.C. (Distribution by official request).

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CANADIAN RADIOACTIVE FALLOUT STUDY PROGRAM

January 1963

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program (RFSP), the Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation at 24 stations located at airports (see figure 2). The sampling equipment at these stations is operated by meteorologists of the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in the Department's reports (*1-5*).

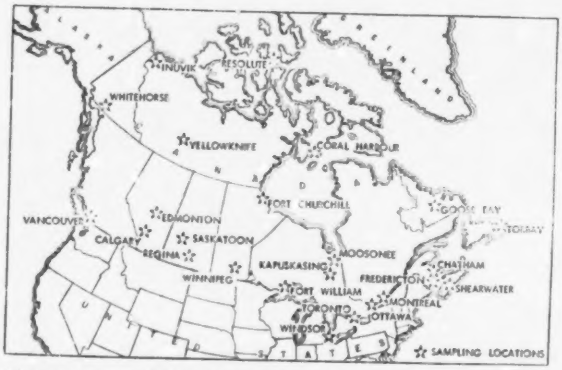

FIGURE 2.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS

Air

In the collection of air samples, about 650 cubic meters of air are drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is removed from each filter and counted with a thin-end-window Geiger flow counter system, calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to allow for the presence of natural activities and for the decay of short-lived fission products. The result is extrapolated to the end of the sampling period. Canadian air data for January 1963 are given in table 3, and presented in conjunction with U. S. adjusted air data in the concentration contour map (figure 3).

Precipitation

The amount of radioactive fallout being deposited on the ground is determined from measurements on material collected in special polythene-lined rainfall pots. After transfer of the water to the sampling container, the polythene liner is removed, packed with the sample, and sent to the laboratory. January 1963 precipitation data for Canada, including some radiochemical analyses, are shown in table 4.

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN AIR, RFSP, JANUARY 1963

[Average concentrations in μμc/m³]

Station	Number of samples	Maximum	Minimum	Average
Calgary	29	42.0	2.1	17.7
Coral Harbour	30	13.0	0.0	4.4
Edmonton	28	31.0	3.1	11.3
Ft. Churchill	30	8.2	1.0	4.8
Ft. William	30	18.4	2.2	9.4
Fredericton	31	19.8	0.8	9.6
Goose Bay	30	10.7	1.1	5.6
Inuvik	31	29.0	3.6	11.8
Montreal	31	25.0	4.9	11.5
Moosonee	27	29.5	2.3	9.0
Ottawa	31	27.0	4.2	12.4
Regina	30	31.0	3.9	13.6
Resolute	29	11.0	0.8	5.7
Saskatoon	31	36.0	4.2	13.9
Sault Ste. Marie	31	23.2	2.8	11.5
Shearwater	31	33.0	0.6	11.1
Torbay	31	26.2	1.0	10.1
Toronto	30	41.0	4.8	14.6
Vancouver	31	38.0	0.9	12.1
Whitehorse	30	26.0	2.6	9.6
Windsor	31	22.0	5.6	14.1
Winnipeg	30	20.0	2.7	10.0
Yellowknife	31	16.2	4.5	9.6
Average				10.6

Recent coverage in *Radiological Health Data:*

Period	Issue
Third quarter 1961	*May 1962*
Fourth quarter 1961	*September 1962*
First quarter 1962	*October 1962*
Second and third quarters 1962	*January 1963*
October 1962	*February 1963*
November 1962	*March 1963*
December 1962	*April 1963*

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TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, RFSP, JANUARY 1963

Station	Total beta activity		Deposition of specific radionuclides for selected samples[1, 2] (mμc/m³)				
	μμc/liter	mμc/m³	Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ba^{140}
Calgary	3,308	84.0	5.00	0.25	13.4	0.35	3.06
Coral Harbour	3,462	64.5					
Edmonton	2,523	93.5					
Fredericton	991	110.6					
Fort Churchill	1,287	31.1					
Fort William	4,478	54.6					
Goose Bay	613	67.3					
Inuvik	3,139	114.0					
Montreal	1,594	66.4	6.35	0.25	9.86	0.47	2.50
Moosonee	1,111	33.0					
Ottawa	1,674	63.7					
Quebec	757	49.1					
Regina	6,545	29.9					
Resolute	4,618	140.7					
Saskatoon	2,377	39.4					
Sault Ste. Marie	1,234	65.5					
Shearwater	1,415	204.5	11.9	0.51	44.5	1.12	7.20
Torbay	1,652	252.5					
Toronto[3]	—	—					
Vancouver	2,181	87.5	10.4	0.47	11.2	0.73	3.37
Whitehorse	3,671	77.7					
Windsor	2,589	73.6					
Winnipeg	6,366	42.0	4.48	0.19	5.70	0.34	2.86
Yellowknife	3,118	63.3					
Average	2,887	83.0					

[1] All values corrected for decay back to end of collection month.

[2] Values for strontium-90, cesium-137, and zirconium-95 do not include the activities of their daughter isotopes, yttrium-90, barium-137, and niobium-95.

[3] No sample.

REFERENCES

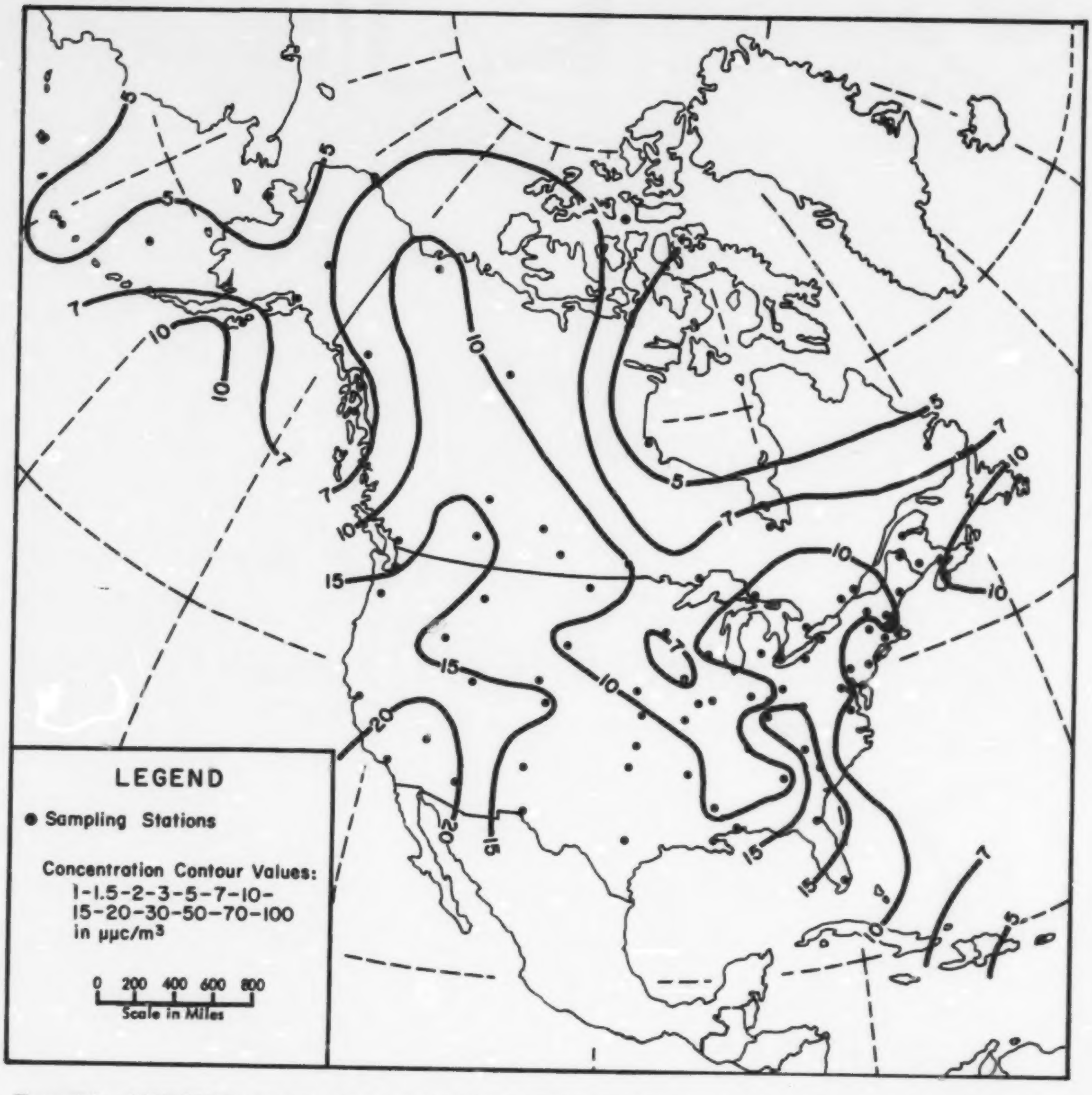
(*1*) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1959 on the Radioactive Fallout Study Program, CNHW (RPD-3)*, (May 1960).

(*2*) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW (RPD-4)* (December 1961).

(*3*) Mar, P. G.: *Outline of Procedure for the Radiochemical Analysis of Dried Milk Powders for Strontium and Yttrium, CNHW (RPD-5)*, (June 1, 1960).

(*4*) Beale, J. and J. Gordon: *The Operation of the Radiation Protection Division Air Monitoring Program, CNHW (RPD-11)*, (July 1962).

(*5*) Booth, A. H.: *The Calculation of Maximum Permissible Levels of Fallout in Air and Water and Their Use in Assessing the Significance of 1961 Levels in Canada, CNHW (RPD-21)*, (August 1962).


LEGEND
● Sampling Stations
Concentration Contour Values:
1-1.5-2-3-5-7-10-
15-20-30-50-70-100
in μμc/m³
0 200 400 600 800
Scale in Miles
5
5
5
7
10
10
7
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7
10
15
15
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5

FIGURE 3.—AIRBORNE GROSS BETA CONCENTRATION CONTOURS FOR CANADA AND THE U. S. JANUARY 1963

MEXICAN RADIOACTIVE FALLOUT PROGRAM

January 1963

Radiological Protection Program National Commission of Nuclear Energy, Mexico

The Radiation Surveillance Network of Mexico was established by the Comisíon Nacional de Energía Nuclear (CNEN) through its Radiological Protection Program (RPP) in 1961 to provide a means for determining increased levels of radioactivity in air and precipitation due to fallout from nuclear tests.

Prior to the establishment of the network, two pilot sampling stations were set up in Mexico City and San Luis Potosí to aid in the selection of equipment and sampling sites. Since April 1962 the network has been expanded to twelve stations, eleven of which were in operation by the end of January 1963.

Eight of the twelve stations are located at airports and operated by airline personnel. The remaining four stations are located at Mexico City, Mérida, Veracruz, and San Luis Potosí. Staff members of the RPP operate the station at Mexico City, while the other three stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, and the Instituto de Zonas Desérticas of the University of San Luis Potosí, respectively.

In December 1962, the station located in Tijuana was moved to Ensenada, a city on the Pacific Coast 60 miles from Tijuana, where it is operated by the staff members of the Escuela Superior de Ciencias Marinas of the University of Baja, California.

Sampling

The sampling procedure involves drawing air 24 hours a day, 3 or 4 days a week at the rate of approximately 1,200 cubic meters per day, through a 6" x 8" high-efficiency glass fiber filter using high-volume samplers. After each 24-hour period, the filter is removed and airmailed to the Laboratorio de Desechos Radiactivos (CNEN) in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughters. Data are not extrapolated to time of collection.

The maximum, minimum, and average fission-product beta concentrations in surface air during January 1963 are presented in table 5.

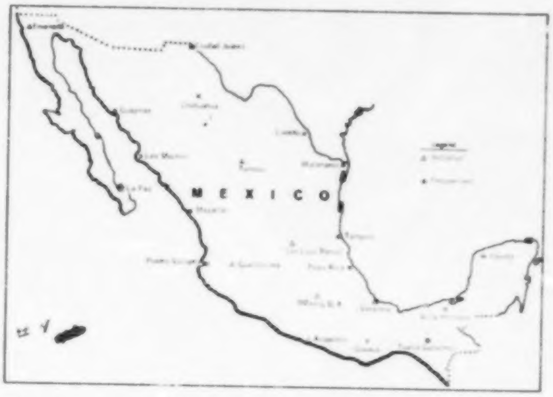

FIGURE 4.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

TABLE 5.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, JANUARY 1963

[Concentrations in $\mu\mu c/m^3$]

Station	Number of samples	Maximum	Minimum	Average
Acapulco	5	5.5	0.6	3.96
Ciudad Juárez	6	29.9	9.2	22.55
Ensenada	13	39.9	10.7	16.73
Guadalajara	12	14.2	1.8	5.78
La Paz	14	19.7	4.0	9.37
Mérida	15	42.6	3.3	12.97
México	12	4.2	2.1	3.35
San Luis Potosí	12	9.3	1.4	5.50
Torreón	12	38.5	3.5	13.96
Veracruz	21	17.8	0.4	4.15
Tuxtla Gutierrez	19	15.4	0.15	4.58

SECTION II.—MILK

Milk Surveillance

Produced and consumed on a regular basis, milk is convenient to handle, is easily analyzed, and representative samples of milk consumed in any given area are easily obtained. Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment because fresh milk is consumed by a large segment of the U. S. population and contains most of the radionuclides identified as being biologically important.

PASTEURIZED MILK NETWORK

January 1963 and Annual Summary for 1962

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

JANUARY 1963

Raw milk studies were started by the Public Health Service in 1957 to determine relationships between dairy practices and radionuclide levels in milk. However, it became evident that the milk actually consumed by the population should be included in a broader sampling program. In 1960 the pasteurized milk network was initiated to provide data representative of the milk consumed in selected municipalities. Both raw and pasteurized milk sampling and analytical data were reported concurrently until June 1961 to permit comparison of the differences between the earlier, limited, milkshed sampling results and those exhibited in pasteurized milk monitoring. Since June 1961, raw milk sampling has been carried out for investigative rather than monitoring purposes.

During January 1963, pasteurized milk surveillance was conducted at 62 Pasteurized Milk Network stations with the cooperation of State and local milk sanitation agencies. These samples, preserved with formaldehyde, are sent to the PHS Southwestern, Southeastern, and Northeastern Radiological Health Laboratories for analyses. Data from gamma analyses (iodine-131) are available to State public health officials and the Federal Radiation Council approximately 3 to 6 days after sample collection for possible public health action. Publication in *Radiological Health Data* follows 3 to 4 months after sample collection because of the time required for shipment, processing, radioanalysis of strontium, data compilation, and publication procedures.

Sampling and Compositing Procedures

The current program emphasizes (1) measurement of the concentrations of radioactivity in samples of pasteurized milk consumed by the public in various regions of the country, and (2) provision of at least one sampling point within virtually all States; additional points to be established when the requirements are indicated by widely varying conditions of the milk supply or when needed in order to cover large population groups. Each sample is a composite of subsamples which are specified to be collected from each plant in proportion to the relative volumes of milk sold. Each of the 62 stations reflects from 80 to 100 percent of the milk consumed in that city, with the network average being about 90 percent. Prior to September 15, 1961, the composite of a sample was taken from one day's sales per month and was as representative of a community's total supply as could be achieved under practical conditions. Since the resumption of nuclear weapons testing, the sampling frequency has been increased. During January 1963, most stations were sampled twice a week. All surveillance data are subject to continuing review and evaluation to observe unusual patterns or concentrations which may require immediate attention. Further atmospheric nuclear testing may require re-evaluation and adjustment of the sampling frequency and analytical schedule for this program.

Minimum Reportable Concentrations

Iodine-131, cesium-137, and barium-140 are determined by gamma scintillation spectroscopy,[1] while strontium-89 and strontium-90 are determined by radiochemical procedures. Minimum reportable concentrations used, in units of $\mu\mu c$/liter are: Sr^{89}, 5; Sr^{90}, 1; I^{131}, 10; Cs^{137}, 5; and Ba^{140}, 10.

Milk Collection and Distribution Times

A number of factors influence the concentration of radionuclides in milk. One factor (which may not be the most important) is the decay of radionuclides, particularly the short-lived ones, due to transfer times involved in collection and distribution of milk.

Table 1 gives a rough estimate of the times involved in the movement of pasteurized whole milk through the various stages from production to consumption. The headings in table 1 may be explained by the following statements. "Milking to processing plant" is the time required for storage on the farm and pickup and delivery to the processing plant. "In Processing plant" includes the time for storing raw milk in the processing plant, pasteurizing, transferring the milk through the plant, and storing the processed milk in cartons. "Processing plant to consumer purchase" is the time for delivering the milk from the processing plant to retail outlets and storing in the retail store. "Consumer purchase to consumption" is the time the milk is kept by the consumer before consumption in the usual liquid form. Thus, "Total time, milking to consumption" is the estimated total time between the time of milking and the consumption of the pasteurized fluid milk.

The ranges shown in table 1 do not imply that some milk processing plants distribute milk that is fresher than others. The chain of milk production involves assembling small quantities of milk from many individual farms into larger volumes for processing. The assembled milk is a composite of the times shown in the range. Consequently, part of the milk in a carton will be fresher than another part. Modern standards of biological cleanliness are high and the actual age difference between the fractions of milk in the carton has little bacteriological significance.

However, the total elapsed time is important in assessing the radiation dose from a short-lived nuclide such as iodine-131 ($T_{\frac{1}{2}}$ = 8.05 days). Figure 1 presents graphically the effect of the radioactive decay of iodine-131. Although analyses of milk samples are performed 1 to 4 days after collection, the data presented in table 2 have been

TABLE 1.—NORMAL TIMES REQUIRED FOR THE MOVEMENT OF PASTEURIZED WHOLE MILK FROM THE FARM TO THE CONSUMER[1]

	Time in hours required for:				
	Milking to processing plant	In processing plant	Processing plant to consumer purchase	Consumer purchase to consumption	Total time, milking to consumption
Range	2–44	1–8	0–48	0–72	3–148
Average	23	4.5	24	36	75.5

[1] Data supplied by the Milk Industry Foundation.

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[1] See page 139 of March *Radiological Health Data*.

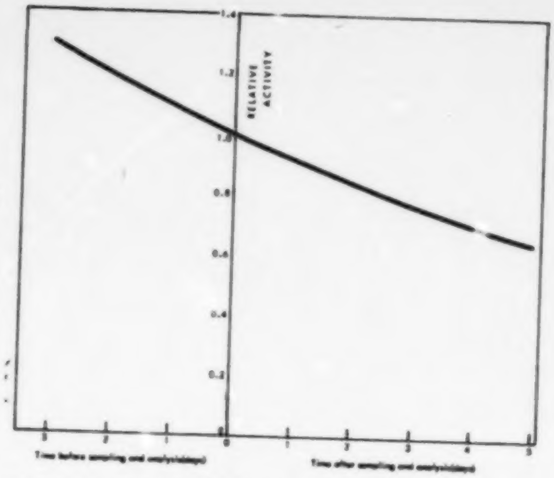


FIGURE 1.—RELATIVE DECAY OF IODINE-131 (HALF-LIFE = 8.05 DAYS)

extrapolated to the time of collection. Samples are usually collected from cartons at or near the end of the processing period.

Data Presentation

Table 2 presents summaries of all available analyses for January 1963 (December 30, 1962-January 26, 1963). When a radionuclide is reported by a laboratory as being below the minimum detectable concentration, one-half of this value is used in calculating the monthly average. A similar procedure is used for the network average. Although no data are presented on the stable potassium concentrations in milk, analysis has indicated that the usual range of concentrations is from 1.4 to 1.7 grams/liter. In January, for example, 12, 18, 24, and 4 stations reported respective monthly average potassium concentrations to be 1.4, 1.5, 1.6, and 1.7 grams/liter.

Figures 2-4 are concentration contour maps showing the estimated radionuclide concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station.

Discussion of Data

In January 1963 the amount of iodine-131 appearing in milk (figure 2) over the entire country changed abruptly from that for the previous month. During December 1962 most of the country had monthly average concentrations from 20 to

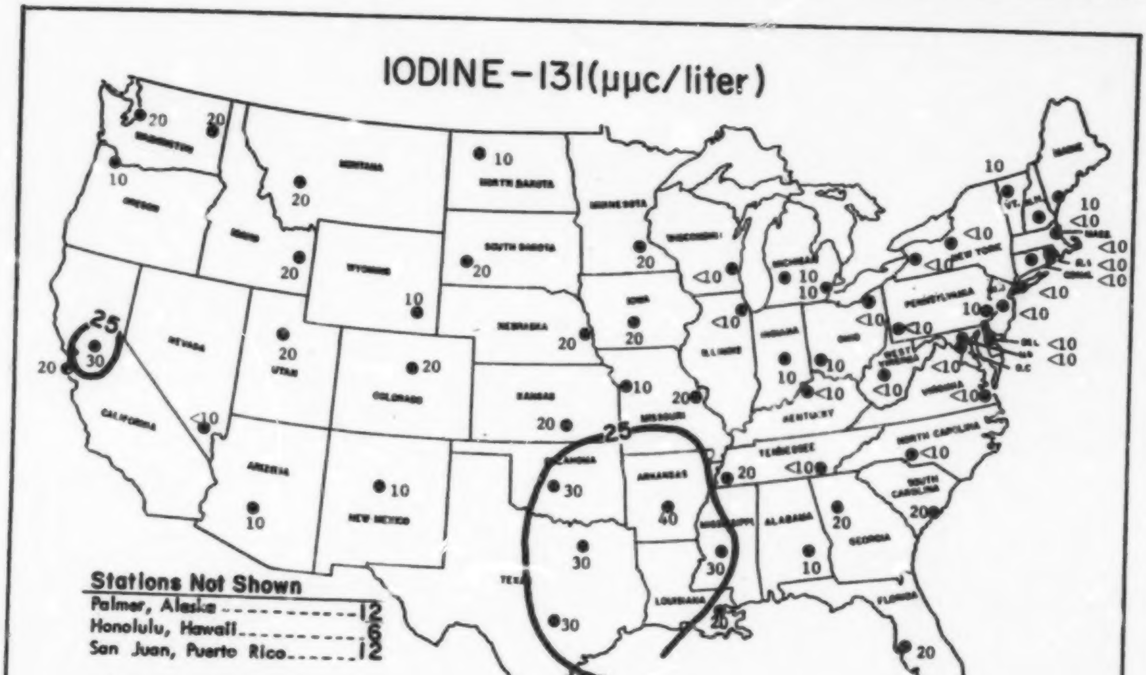


FIGURE 2.—IODINE-131 CONCENTRATIONS IN PASTEURIZED MILK

TABLE 2. RADIOACTIVITY IN PASTEURIZED MILK, JANUARY 1963

[Average radioactivity concentrations in μμc/liter]

Sampling locations		Calcium (g/liter)		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
		Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month
Ala:	Montgomery	1.26	1.28	40	80	15	15	40	10	35	45	20	10
Alaska:	Palmer	1.33	1.24	80	25	13	12	110	20	60	85	30	10
Ariz:	Phoenix	1.32	1.26	25	25	5	4	20	10	20	20	<10	<10
Ark:	Little Rock	1.26	1.23	120	125	29	29	110	40	70	70	30	20
Calif:	Sacramento	1.32	1.29	20	15	4	3	20	30	20	25	10	<10
	San Francisco	1.34	1.34	20	60	4	5	20	20	20	25	<10	20
Colo:	Denver	1.34	1.34	20	10	11	13	20	20	55	70	<10	<10
Conn:	Hartford	1.13	1.12	40	5	11	12	40	<10	65	70	10	<10
Del:	Wilmington	1.11	1.16	50	10	15	16	80	<10	70	75	20	<10
D. C:	Washington	1.20	1.21	40	10	18	13	60	<10	55	55	20	<10
Fla:	Tampa	1.25	1.24	30	30	10	12	50	20	125	100	10	<10
Ga:	Atlanta	1.24	1.25	55	85	17	18	60	20	55	70	20	10
Hawaii:	Honolulu	1.26	1.19	20	40	6	6	20	20	40	45	<10	<10
Idaho:	Idaho Falls	1.31	1.25	25	10	13	13	40	20	75	75	10	10
Ill:	Chicago	1.12	1.12	45	<5	12	14	70	<10	65	75	10	<10
Ind:	Indianapolis	1.17	1.16	50	10	13	15	80	10	55	65	10	<10
Iowa:	Des Moines	1.36	1.28	75	20	14	14	110	20	50	60	20	<10
Kans:	Wichita	1.34	1.32	55	30	13	12	70	20	40	50	20	<10
Ky:	Louisville	1.23	1.23	95	30	23	21	80	<10	45	55	40	<10
La:	New Orleans	1.28	1.27	70	160	24	30	70	20	60	75	20	20
Maine:	Portland	1.15	1.09	50	<5	17	20	50	10	110	105	20	<10
Md:	Baltimore	1.22	1.22	40	<5	17	15	60	<10	60	60	20	<10
Mass:	Boston	1.13	1.16	60	5	19	18	50	<10	100	100	20	<10
Mich:	Detroit	1.13	1.16	50	5	15	16	70	10	75	75	20	<10
	Grand Rapids	1.18	1.18	35	10	12	16	50	10	65	75	10	<10
Minn:	Minneapolis	1.32	1.24	70	15	23	20	70	20	95	105	30	<10
Miss:	Jackson	1.30	1.34	90	170	19	25	70	30	45	55	30	20
Mo:	Kansas City	1.33	1.28	100	30	17	16	120	10	45	45	30	<10
	St. Louis	1.35	1.28	55	20	14	12	60	20	45	60	20	10
Mont:	Helena	1.35	1.30	45	25	16	14	80	20	85	90	30	20
Nebr:	Omaha	1.37	1.36	60	25	15	16	90	20	55	60	20	10
Nev:	Las Vegas	1.26	1.19	25	10	6	6	10	<10	40	40	<10	<10
N. H:	Manchester	1.16	1.16	50	5	18	20	40	<10	115	110	10	<10
N. J:	Trenton	1.12	1.14	45	<5	13	14	60	<10	65	65	20	<10
N. Mex:	Albuquerque	1.33	1.28	20	20	5	6	30	10	25	30	20	<10
N. Y:	Buffalo	1.10	1.11	40	10	13	15	40	<10	80	90	10	<10
	New York	1.13	1.09	55	<5	17	16	80	<10	75	70	20	<10
	Syracuse	1.14	1.10	45	<5	14	16	50	<10	65	70	10	<10
N. C:	Charlotte	1.27	1.25	50	25	19	25	20	<10	50	50	20	<10
N. D:	Minot	1.34	1.27	60	15	27	28	60	10	65	90	20	20
Ohio:	Cincinnati	1.16	1.13	60	20	17	18	90	10	45	55	10	<10
	Cleveland	1.16	1.18	50	5	14	15	70	<10	60	60	<10	<10
Okla:	Oklahoma City	1.21	1.24	65	65	17	17	100	30	40	50	20	20
Ore:	Portland	1.40	1.32	150	70	18	12	60	10	80	70	40	30
Pa:	Philadelphia	1.13	1.12	45	10	14	18	80	10	60	70	10	<10
	Pittsburgh	1.14	1.15	55	<5	19	19	110	<10	80	80	20	<10
P. R:	San Juan	1.17	1.24	75	150	10	12	30	30	45	55	10	30
R. I:	Providence	1.11	1.15	45	10	16	14	60	<10	85	80	20	<10
S. C:	Charleston	1.26	1.24	50	60	20	20	40	20	60	65	20	10
S. D:	Rapid City	1.17	1.14	50	25	15	15	70	20	70	85	20	<10
Tenn:	Chattanooga	1.28	1.31	95	70	20	22	60	<10	50	50	30	<10
	Memphis	1.25	1.28	85	95	20	22	80	20	40	45	30	20
Tex:	Austin	1.23	1.24	35	70	8	9	90	30	30	25	20	10
	Dallas	1.23	1.28	90	130	16	18	150	30	45	55	30	20
Utah:	Salt Lake City	1.35	1.31	30	15	11	12	40	20	75	95	30	<10
Vt:	Burlington	1.11	1.15	55	5	13	16	60	<10	85	90	20	<10
Va:	Norfolk	1.23	1.24	45	20	20	18	50	<10	60	60	20	<10
Wash:	Seattle	1.36	1.30	100	35	21	9	60	20	85	75	40	<10
	Spokane	1.40	1.33	35	20	15	13	30	20	80	90	10	<10
W. Va:	Charleston	1.22	1.25	60	15	21	19	40	<10	55	45	20	10
Wis:	Milwaukee	1.18	1.15	45	10	11	9	90	<10	70	65	20	<10
Wyo:	Laramie	1.32	1.28	45	20	12	15	20	10	80	95	10	<10
Network average		1.24	1.23	55	34	15.1	15.4	61	14	62	66	19	<10

200 μμc/liter, while in January 1963 most of the stations reported from <10 to 20 μμc/liter. The Mississippi Valley area was the area with the greatest concentrations during both months. December 1962 iodine-131 concentrations of 100 to 330 μμc/liter were observed in this area while January 1963 averages were from 20 to 40 μμc/liter.

The monthly average strontium-89 concentrations in milk for January 1963 are similar to those in December 1962 in most areas (see figure 3). In January 1963 strontium-89 concentrations generally were below 50 μμc/liter.

Monthly average strontium-90 concentrations in milk for January 1963 were also similar to the ones in December 1962. Most stations reported

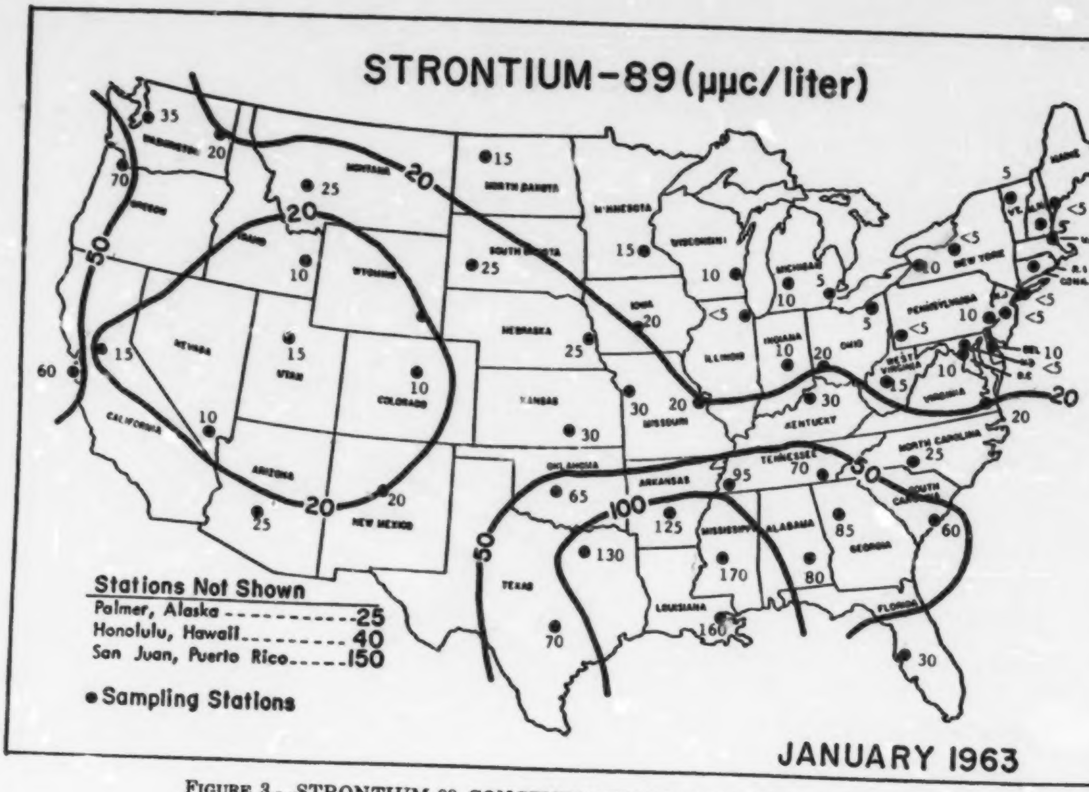

STRONTIUM-89 (μμc/liter)
Stations Not Shown
Palmer, Alaska 25
Honolulu, Hawaii 40
San Juan, Puerto Rico 150
● Sampling Stations
JANUARY 1963
20
50
100
35
70
60
15
10
25
65
130
125
170
160
95
85
80
30
<5
5

FIGURE 3.—STRONTIUM-89 CONCENTRATIONS IN PASTEURIZED MILK

concentrations from 10 to 20 μμc/liter (see figure 4). In the Southwest, strontium-90 concentrations below 10 μμc/liter were observed, while the lower Mississippi Valley, together with a region extending eastward through the Carolinas to the coast, experienced concentrations of 20 to 30 μμc/liter. North Dakota and Minnesota also experienced approximately this same range of concentrations.

As mentioned previously, radiostrontium levels did not change appreciably since the previous month, but iodine-131 concentrations in milk dropped sharply. Examination of barium-140 and cesium-137 concentrations for December 1962 and January 1963 shows that barium-140 concentrations in milk decreased while cesium-137 concentrations remained approximately constant. In summary, the concentrations of the "long-lived" nuclides remained approximately constant while the concentrations of "short-lived" nuclides decreased from December 1962 to January 1963. Concentrations of strontium-89 ($T_{\frac{1}{2}}$ = 50.5 days) in milk showed a slight decrease.

These observations might be explained by one or more of the following presumptive factors:

1. A relatively low total fallout occurred in January 1963 as compared with December 1962.
2. The relative proportion of short to long-lived radionuclides in January fallout was less than that in December fallout.

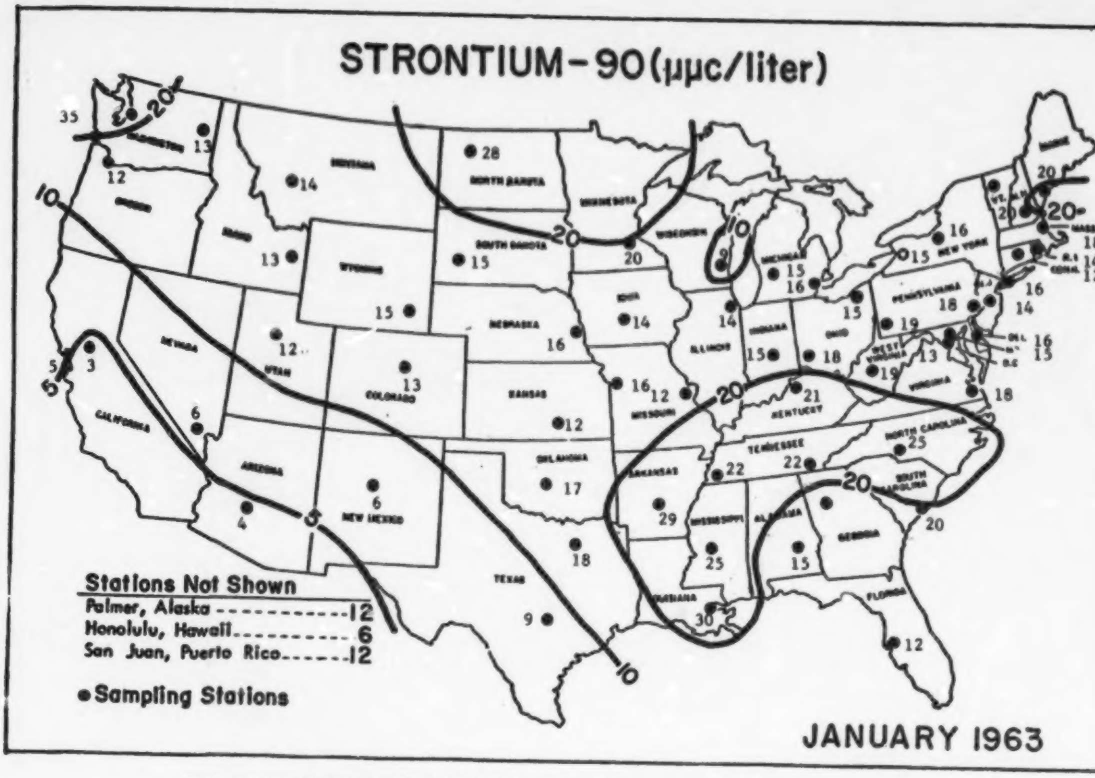

STRONTIUM-90 (μμc/liter)
Stations Not Shown
Palmer, Alaska 12
Honolulu, Hawaii 6
San Juan, Puerto Rico 12
● Sampling Stations
JANUARY 1963

FIGURE 4.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

3. In January, cows consumed feed which contained relatively little fresh fallout as opposed to December (e.g., relatively more stored feed than pasturage was used).

Deposition data were not available to confirm or disprove that factors 1 and 2 were operative. However, additional information secured concerning factor 3 indicates that, during the first week of January, mild weather permitted livestock throughout the Great Plains Region to feed from Pastures (*1*). In the lower Ohio Valley, the lower Mississippi Valley, and eastward there was limited grazing due to damage to winter pastures. During the latter three weeks of January, snow and low temperature conditions forced cattle from the pasture and pushed supplemental feeding to high levels throughout the nation.

Selected Monthly Strontium-90 Profiles

Continuing the practice of previous issues of *RHD*, figure 5 presents the average monthly strontium-90 concentrations in pasteurized milk from 16 additional cities in the sampling program. Each individual graph shows the strontium-90 concentrations in milk from one city in each of the four U.S. Bureau of Census regions.

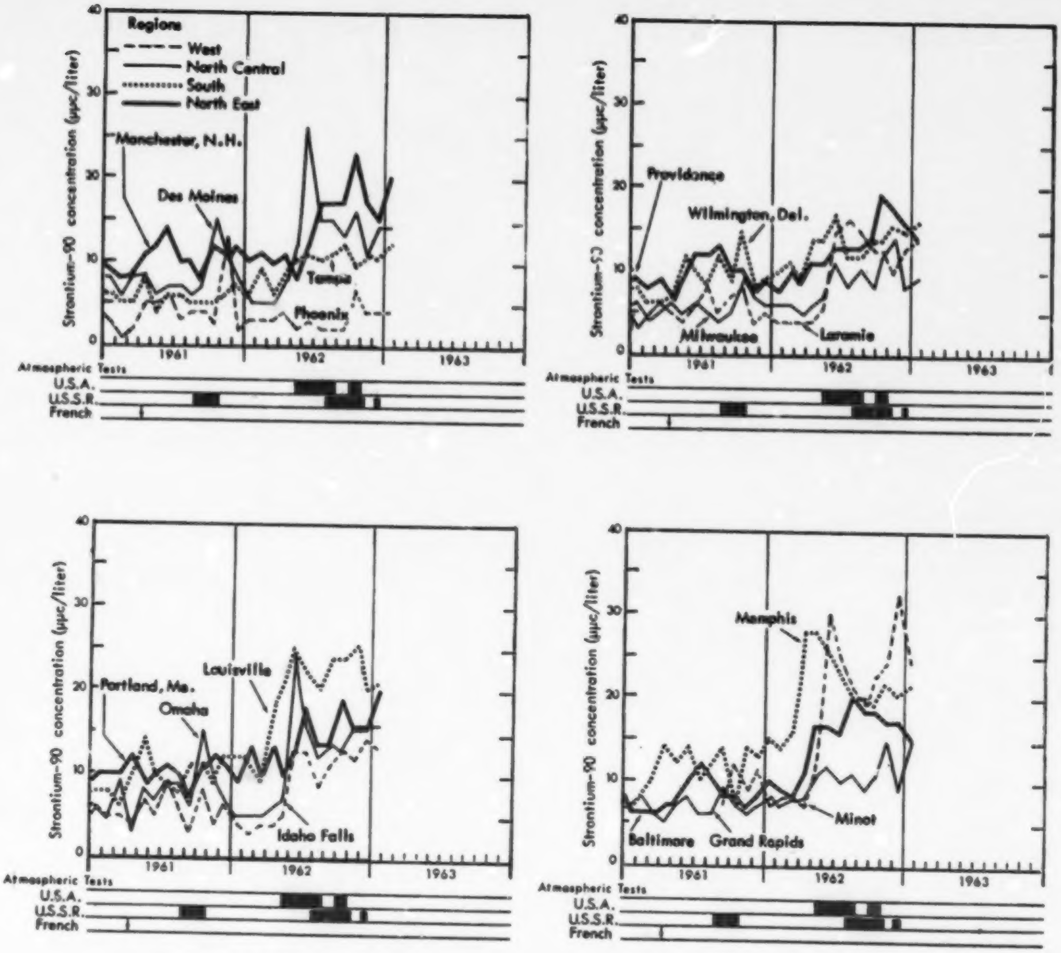


FIGURE 5.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

ANNUAL SUMMARY FOR 1962

The annual average radionuclide concentrations in the Pasteurized Milk Network have been summarized for calendar year 1962 and appear in table 3 below. Included are values for stable calcium and five nuclides of primary importance. Comparable tabular data for 1960 and 1961 have been published previously (2).

The annual average values in the table have been compiled from weekly as opposed to monthly averages. This procedure is dictated since each "month", for which monthly radionuclide averages have been published in 1962 contains either four or five weeks depending on the number of full weeks ending within each calendar month. This avoids a possible bias introduced by averaging unequal units of time (months). The year 1962 extends from January 1, 1962 through December 29, 1962. In averaging, when a radionuclide concentration is reported as being below the minimum detectable value, one half of this value is used in the calculations. Where an "average" is determined below this minimum detectable value, the minimum detectable value preceded by a "less than" sign is the reported average.

Figures 6-11 show the geographical distribution of strontium-89 and iodine-131 for 1961 and 1962, and strontium-90 for 1961 and 1962. The values shown on the figures at each station represent the yearly average for that station.

Discussion

The 1960 average for strontium-89 was below the detectable limit since there was no atmospheric nuclear testing since 1958. With the resumed test-

TABLE 3.—ANNUAL SUMMARIES OF RADIOACTIVITY IN PASTEURIZED MILK, 1962

[Average radioactivity concentrations in μμc/liter]

Sampling locations		Calcium (g/liter)	Strontium-89	Strontium-90	Iodine-131	Cesium-137	Barium-140
Ala:	Montgomery[a]	1.21	59	15	18	37	17
Alaska:	Palmer	1.14	51	10	104	37	21
Ariz:	Phoenix	1.13	18	3	12	12	<10
Ark:	Little Rock	1.21	133	29	87	62	27
Calif:	Sacramento	1.15	19	4	12	14	<10
	San Francisco	1.17	32	5	14	17	10
Colo:	Denver	1.17	29	10	15	38	<10
Conn:	Hartford	1.14	22	11	21	45	<10
Del:	Wilmington	1.14	36	13	32	49	<10
D. C:	Washington	1.17	35	14	23	40	11
Fla:	Tampa	1.23	25	10	16	108	<10
Ga:	Atlanta	1.21	84	18	23	57	17
Hawaii:	Honolulu	1.11	27	5	12	27	<10
Idaho:	Idaho Falls	1.14	24	9	25	44	12
Ill:	Chicago	1.14	30	11	38	39	<10
Ind:	Indianapolis	1.17	38	13	33	35	<10
Iowa:	Des Moines	1.15	65	12	59	32	17
Kans:	Wichita	1.15	50	11	59	27	13
Ky:	Louisville	1.19	76	19	29	33	19
La:	New Orleans	1.24	170	30	23	86	29
Maine:	Portland	1.18	30	14	22	75	<10
Md:	Baltimore	1.18	33	15	24	45	10
Mass:	Boston	1.15	31	16	22	76	10
Mich:	Detroit	1.14	27	11	35	44	<10
	Grand Rapids	1.19	23	10	26	42	<10
Minn:	Minneapolis	1.14	55	16	43	58	19
Miss:	Jackson	1.27	154	24	23	56	29
Mo:	Kansas City	1.14	84	14	84	29	25
	St. Louis	1.14	53	13	33	32	17
Mont:	Helena	1.16	44	12	40	50	17
Nebr:	Omaha	1.18	57	13	53	32	15
Nev:	Las Vegas[b]	—	—	—	—	—	—
N. H:	Manchester	1.15	28	14	20	87	<10
N. J:	Trenton	1.13	27	11	22	39	<10
N. Mex:	Albuquerque	1.15	17	4	21	14	12
N. Y:	Buffalo	1.12	24	11	24	50	<10
	New York	1.12	29	14	32	51	<10
	Syracuse	1.14	26	11	27	40	<10
N. C:	Charlotte	1.23	56	19	9	39	13
N. Dak:	Minot	1.15	45	18	41	49	13
Ohio:	Cincinnati	1.16	48	14	39	30	<10
	Cleveland	1.15	29	12	31	38	<10
Okla:	Oklahoma City	1.17	70	17	48	37	18
Ore:	Portland	1.18	82	13	27	53	17
Pa:	Philadelphia	1.15	28	12	29	45	<10
	Pittsburgh	1.15	34	15	40	53	<10
P. R:	San Juan[c]	1.16	71	10	14	40	14
R. I:	Providence	1.14	25	12	23	58	<10
S. C:	Charleston	1.22	68	19	17	56	13
S. Dak:	Rapid City	1.10	54	15	39	46	16
Tenn:	Chattanooga	1.25	117	22	22	56	23
	Memphis	1.22	105	21	27	28	24
Tex:	Austin	1.18	28	7	28	20	10
	Dallas	1.20	76	15	49	34	17
Utah:	Salt Lake City	1.16	30	9	87	52	19
Vt:	Burlington	1.12	30	11	23	58	<10
Va:	Norfolk	1.21	47	17	18	49	11
Wash:	Seattle	1.16	59	15	27	61	18
	Spokane	1.19	36	12	59	49	<10
W. Va:	Charleston	1.18	57	16	19	35	15
Wis:	Milwaukee	1.17	23	8	39	37	<10
Wyo:	Laramie	1.14	52	10	55	56	19
Network average		1.17	50	13.4	32	45	12

[a] Averages for calcium (g/liter) and for barium-140 are for 11 months. No data for February 1962.

[b] No averages are given for Las Vegas since the station has not been in the Pasteurized Milk Network for the entire year.

[c] Averages are for 11 months. No data for November 1962.

ing of nuclear devices in September 1961, strontium-89 reappeared, as shown in the 1961 average values. Most of the U.S. reported averages for strontium-89 of below 20 μμc/liter. The States immediately west of the Mississippi River however, averaged yearly concentrations of strontium-89 of 20 to 30 μμc/liter. In 1962, the concentrations were higher. Most of the country had yearly strontium-89 concentrations of 20 to 101 μμc/liter. The Southwest reported values below 20 μμc/liter, while in the lower Mississippi valley concentrations of 100 to 170 μμc/liter were recorded.

The 1960 average strontium -90 concentrations were 13 μμc/liter throughout the entire country. The Southwest showed a yearly average of below 5 μμc/liter. The resumption of atmospheric nuclear testing did not appreciably increase the yearly average strontium-90 content of milk for 1961.

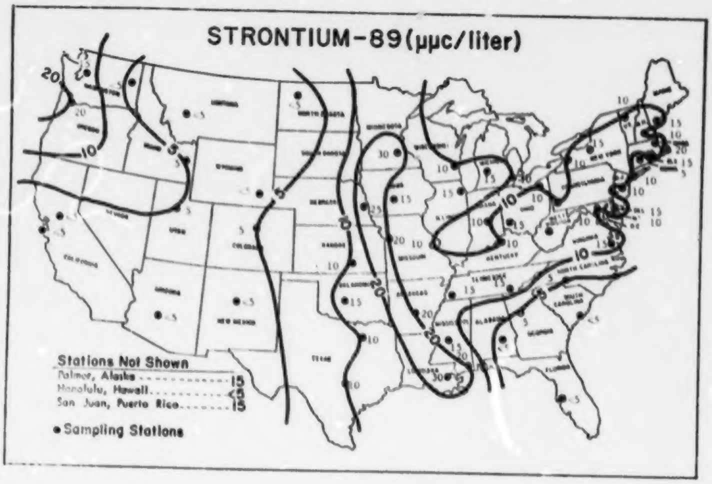

STRONTIUM-89(μμc/liter)
Stations Not Shown
Palmer, Alaska 15
Honolulu, Hawaii <5
San Juan, Puerto Rico 15
● Sampling Stations

FIGURE 6.—ANNUAL AVERAGE STRONTIUM-89 CONCENTRATIONS IN PASTEURIZED MILK, 1961

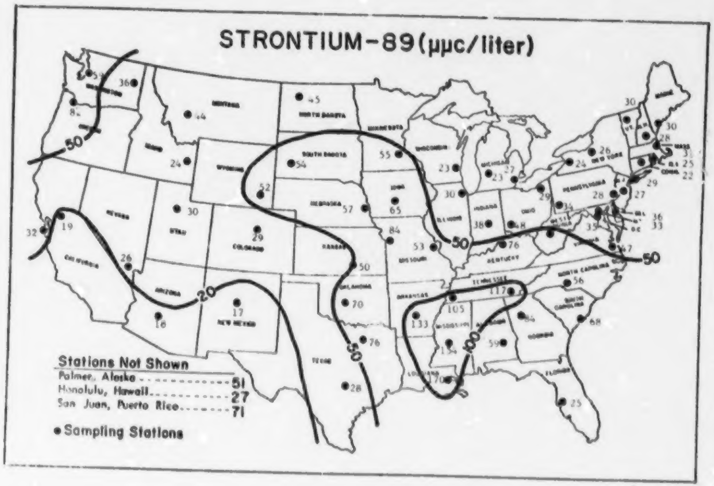

STRONTIUM-89(μμc/liter)
Stations Not Shown
Palmer, Alaska 51
Honolulu, Hawaii 27
San Juan, Puerto Rico 71
● Sampling Stations

FIGURE 7.—ANNUAL AVERAGE STRONTIUM-89 CONCENTRATIONS IN PASTEURIZED MILK, 1962

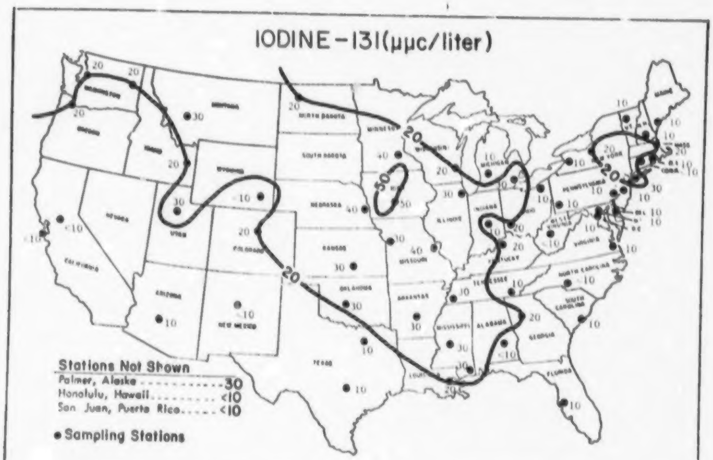

IODINE-131(μμc/liter)
Stations Not Shown
Palmer, Alaska 30
Honolulu, Hawaii <10
San Juan, Puerto Rico <10
● Sampling Stations

FIGURE 8.—ANNUAL AVERAGE IODINE-131 CONCENTRATIONS IN PASTEURIZED MILK, 1961

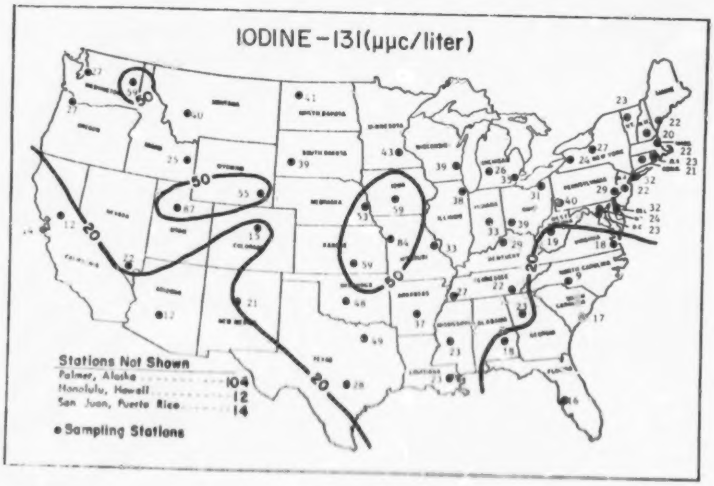
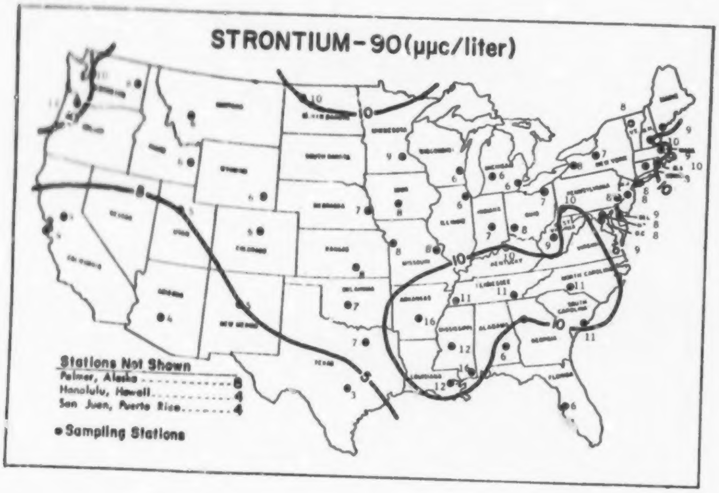

IODINE-131(μμc/liter)
Stations Not Shown
Palmer, Alaska 104
Honolulu, Hawaii 12
San Juan, Puerto Rico 14
• Sampling Stations
50
50
50
20
20
20
20

FIGURE 9.—ANNUAL AVERAGE IODINE-131 CONCENTRATIONS IN PASTEURIZED MILK, 1962

FIGURE 10.—ANNUAL AVERAGE STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, 1961


STRONTIUM-90(μμc/liter)
Stations Not Shown
Palmer, Alaska 8
Honolulu, Hawaii 4
San Juan, Puerto Rico 4
• Sampling Stations
10
10
10
10
5
5

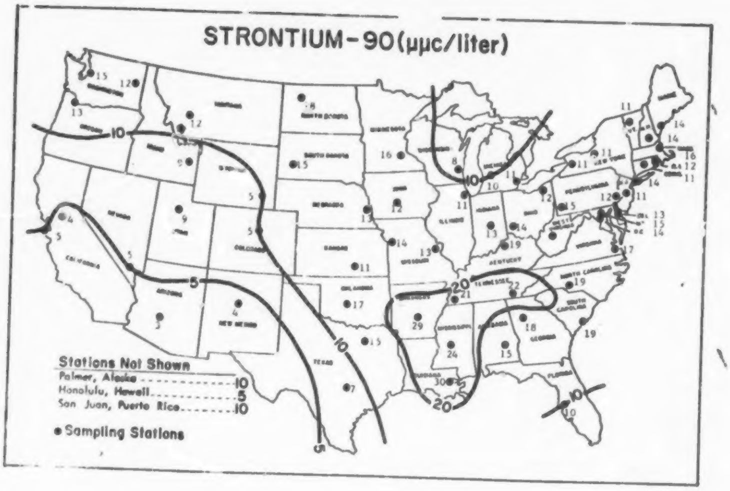

STRONTIUM-90(μμc/liter)
Stations Not Shown
Palmer, Alaska 10
Honolulu, Hawaii 5
San Juan, Puerto Rico 10
• Sampling Stations
10
10
10
10
20
20
5
5
5

FIGURE 11.—ANNUAL AVERAGE STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, 1962

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The national pattern for 1961 appears similar to that for 1960 with the exception that for 1961 one station had an average concentration of 16 μμc/liter; this was the highest annual average concentration observed that year. In 1962, strontium-90 levels generally increased. The lower Mississippi Valley region exhibited a yearly average concentration of 20 to 30 μμc/liter. Values in the Southwest were below 5 μμc/liter; and the balance of the nation reported values intermediate to these.

Iodine-131 was not detectable in milk in 1960. Iodine-131 appeared in the 1961 average with one station reporting a value of 50 μμc/liter, the highest annual average for that year. In 1962, eight stations reported yearly average iodine-131 levels above 50 μμc/liter, the highest being 104 μμc/ liter. Iodine-131 yearly average concentrations differ markedly from the monthly values. While large excursions in the monthly average concentration of iodine-131 occur at various stations, very large monthly differences between stations and between regions were averaged out over the year.

REFERENCES

(1) United States Department of Agriculture Statistical Reporting Service: *Weekly Weather and Crop Bulletin, Volume L*, Nos. 1-4, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (January 1963, price per year $3.00, price per single copy 10 cents.

(2) Public Health Service; Milk Monitoring Program, *Radiological Health Data*, 3:186-91 (June 1962).

CALIFORNIA MILK NETWORK

July–September 1962

State of California, Department of Public Health

Surveillance of the concentrations of specific radionuclides in milk is one phase of California's Department of Public Health program of radiation control. This milk monitoring function has been conducted since 1960 by the Department's Bureau of Radiological Health, a constituent of the Division of Environmental Sanitation.

The surveillance program involves the weekly sampling of milk from 11 major milksheds (see figure 12). Originally, radioanalyses were performed for potassium-40, cesium-137, and strontium-90 and calcium. More recently, interest has broadened to include not only the above but also iodine-131, strontium-89, and barium-lanthanum-140. All milk is now being analyzed for these three radionuclides only.

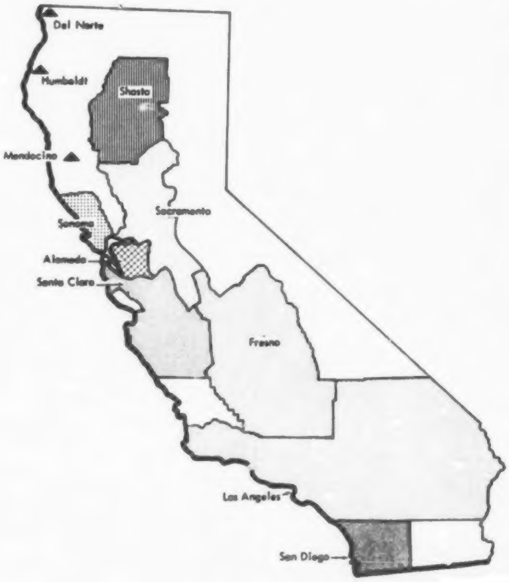

FIGURE 12.—CALIFORNIA MILKSHEDS

Results and Discussion

Table 4 presents strontium-89 and strontium-90 monthly averages for the 11 milksheds from July to September 1962. It should be noted that the units used in table 1 are μμc/g calcium. Comparisons of other data in terms of μμc/liter may be made using the approximate equivalent value of 1.1 grams of calcium per liter of milk. No iodine-131 data are given because all samples indicated that iodine-131 concentrations in milk were below the detectable limit of 10 μμc/liter during the third quarter of 1962.

Del Norte and Humboldt Counties have reported milk with higher strontium-89 and strontium-90 concentrations than the other areas. Strontium-90 concentrations in milk have remained relatively constant from July through September, but strontium-89 concentrations underwent a significant decrease from July through August in all milksheds.

TABLE 4.—RADIONUCLIDES IN CALIFORNIA MILK, JULY-SEPTEMBER 1962

[Concentrations in $\mu\mu c$/g calcium]

Sampling area	Strontium-89			Strontium-90		
	July	August	September	July	August	September
Alameda	22.8	2.9	[a]—	3.9	2.3	—
Del Norte	61.4	44.4	50.3	16.8	19.7	13.8
Fresno	9.8	3.7	2.8	3.4	1.8	1.9
Humboldt	20.3	14.1	21.3	4.9	5.6	6.0
Los Angeles	11.2	2.2	2.2	1.5	1.8	2.1
Mendocino	17.8	9.9	4.3	2.9	3.8	3.6
Sacramento	14.1	3.9	3.2	2.4	2.3	1.9
San Diego	12.2	1.5	1.8	1.8	2.3	1.5
Santa Clara	12.3	3.4	1.8	1.9	1.3	2.0
Shasta	24.0	8.6	5.5	3.8	3.6	3.1
Sonoma	13.1	6.0	3.9	2.8	3.1	2.7

[a] Dash indicates no sample.

CONNECTICUT MILK NETWORK

April 1960–December 1962

Connecticut State
Department of Health

The Connecticut State Department of Health began monitoring pasteurized fluid milk for strontium-89 and strontium-90 in April 1960. During this initial period a monthly composite milk sample, representative of the milk sold in the central area of the State, was collected from the processing plant and analyzed for radiostrontium. Beginning in May 1962, the Department's milk monitoring program was expanded to include the determination of iodine-131, barium-lanthanum-140, and cesium-137 in milk samples collected weekly. Since September 1962, the frequency of this sampling has been twice a week.

In addition to sampling milk sold in the central area of the State during 1961, a three-month composite sample representative of the milk sold in the southeastern section of the State was also collected and analyzed for radiostrontium.

From May 1962 to November 1962, weekly samples were collected from milk dealers in five areas of the State (figure 13). These samples, together with the regular composite sample from the central section of the State, were analyzed for the gamma-emitting nuclides. Collection and analysis of these dealer samples will be reinstated when the cows return to pasture feeding in the spring.

A low-background Geiger counter with a thin end-window and gas-flow chamber is used for counting radiostrontium following chemical separation. Initially, the iodine-131, barium-lanthanum-140, and cesium-137 were determined by gamma-scintillation spectrometry using a 4" x 4" sodium iodide crystal and a single-channel analyzer. In November 1962, a 400-channel analyzer was acquired.

TABLE 5.—YEARLY AVERAGES OF STRONTIUM-89 AND STRONTIUM-90 IN MILK FROM CENTRAL AND SOUTHEAST AREAS OF CONNECTICUT, APRIL 1960–DECEMBER 1962

[Concentrations in $\mu\mu c$/liter]

Year	Strontium-89		Strontium-90	
	Central	Southeast	Central	Southeast
April-December 1960	* —	—	8.1	—
1961	6.1	17.2	7.8	10.7
1962	21.0	—	9.4	—

* Dash indicates not detectable.

The 1960, 1961 and 1962 yearly averages of strontium-89 strontium-90 concentrations in milk are given in table 5. The monthly averages for the data obtained from May 1962 through December 1962 are reported in table 6.

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TABLE 6.—RADIONUCLIDES IN CONNECTICUT MILK, MAY-DECEMBER 1962

[Concentrations in $\mu\mu c$/liter]

Month	Central area* composite samples					Central area dealer samples			Southeast area dealer samples			Southwest area dealer samples			South central area dealer samples			Northeast area dealer samples		
	Sr^{89}	Sr^{90}	I^{131}	Ba-La^{140}	Cs^{137}	I^{131}	Ba-La^{140}	Cs^{137}	I^{131}	Ba-La^{140}	Cs^{137}	I^{131}	Ba-La^{140}	Cs^{137}	I^{131}	Ba-La^{140}	Cs^{137}	I^{131}	Ba-La^{140}	Cs^{137}
May	30	8.0	10	<10	80															
June	49	14.4	<10	<10	80	<10	10	90				<10	10	90	<10	10	90			
July	34	13.9	<10	20	90	<10	<10	100	10	<10	120	<10	10	80						
August	24	11.3	<10	10	70	10	20	80	<10	20	140	<10	10	[illegible]						
September	27	11.5	110	20	60	150	40	70	50	40	60	10	10	[illegible]				20	<10	110
October	34	10.4	90	30	60	80	30	60	70	40	90	80	20	70				160	30	60
November	39	9.5	50	<10	70	60	10	70	120	30	100	60	10	60				70	40	100
December	7.1	8.8	10	<10	70													100	10	90

* Samples also analyzed by Public Health Service laboratory.

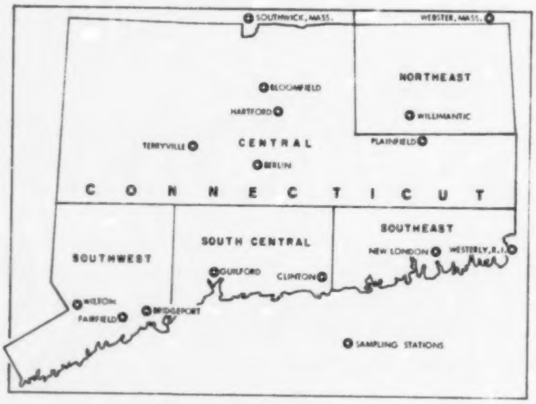
SOUTHWICK, MASS.
WEBSTER, MASS.
NORTHEAST
BLOOMFIELD
HARTFORD
WILLIMANTIC
TERRYVILLE
CENTRAL
PLAINFIELD
BERLIN
CONNECTICUT
SOUTHEAST
SOUTH CENTRAL
SOUTHWEST
NEW LONDON
WESTERLY, R.I.
GUILFORD
CLINTON
WILTON
FAIRFIELD
BRIDGEPORT
SAMPLING STATIONS

FIGURE 13.—CONNECTICUT MILK SAMPLING STATIONS

INDIANA MILK NETWORK

January–February 1963

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analyses in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (see figure 14).

The milk samples are routinely analyzed for iodine-131, cesium-137, barium-lanthanum-140, strontium-89, and strontium-90. Analyses for the gamma emitters iodine-131, cesium-137, and barium-lanthanum-140 are conducted on a weekly basis except when iodine-131 results exceed 100 $\mu\mu c$/liter, at which time the frequency of sampling is increased. Strontium-89 and strontium-90 analyses are performed monthly on samples which are composited from weekly aliquots.

An ion exchange analytical procedure (*1*) is used for strontium-89 and strontium-90 analyses. A 512-channel pulse height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine-131, cesium-137, and barium-lanthanum-140.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 7. The State average is an arithmetic average of the station values.

REFERENCE

(*1*) Porter C., D. Cahill, R. Schneider, P. Robbins, W. Perry, and B. Kahn: Determination of Strontium-90 in Milk by an Ion Exchange Method, *Analytical Chemistry* *33*:1306-8 (September 1961).

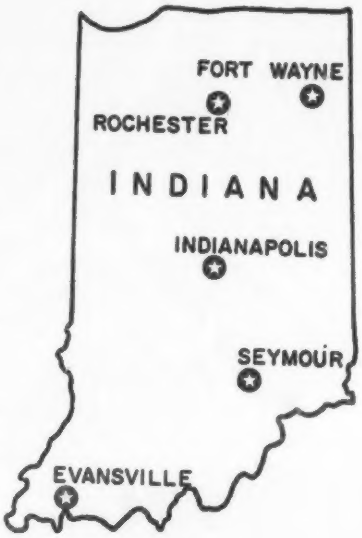
FORT WAYNE
ROCHESTER
INDIANA
INDIANAPOLIS
SEYMOUR
EVANSVILLE

FIGURE 14.—INDIANA MILK SAMPLING LOCATIONS

TABLE 7.—RADIONUCLIDES IN INDIANA MILK, JANUARY–FEBRUARY 1963

[Concentrations in $\mu\mu c$/liter]

Sampling location	Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-Lanthanum-140	
	January	February[a]	January	February[a]	January	February	January	February	January	February
Evansville	20		17		<10	<10	50	40	<10	<10
Fort Wayne	[b]—		18		<10	<10	50	55	<10	<10
Indianapolis	<10		23		<10	<10	55	50	<10	<10
Rochester	<10		22		<10	<10	55	60	<10	<10
Seymour	<10		24		<10	<10	50	60	<10	<10
State average	10		21		<10	<10	50	55	<10	<10

[a] Available next month.

[b] Dash indicates no sample.

NEW YORK MILK NETWORK
November–December 1962

Division of Special Health Services
State of New York Department of Health

Milk samples, collected routinely from six cities —Albany, Buffalo, Massena, Newburgh, New York City, and Syracuse (figure 15), are analyzed for radionuclide content by the State of New York Department of Health. The pasteurized milk samples are collected from processing plants daily and composited weekly for strontium-89, strontium-90, and iodine-131 analyses. The sampling practice at Albany differs in that milk is collected from a marketing point. Also, at Albany and New York City daily samples are analyzed for iodine-131.

In the event that a city reports iodine-131 concentrations exceeding 100 pc/liter, increased surveillance is undertaken. The matrix method (*1*) is used for the analysis of spectral data to determine the concentrations of gamma-emitting nuclides in milk. With this method, the individual nuclide contributions to the gamma spectrum are separated by solution of simultaneous equations describing the spectral interferences.

The analytical procedure for strontium-89 and strontium-90 is based on ion exchange methods to concentrate the strontium, elutriation of strontium isotopes from the ion exchange resin with sodium chloride, gathering by means of sodium carbonate, isolation by means of ethylenediaminetetraacetic acid (EDTA), and counting of radiostrontium with a low background beta counter having a 0.8 mg/cm^2 window. The strontium-90 portion is differentially estimated by a second count 40 hours later to determine the rate of growth of its daughter product, yttrium-90.

Table 8 shows the monthly radionuclide concentration averages for November and December 1962. The numbers in parentheses below the data values are the number of determinations used to compute the monthly average.

REFERENCE

(*1*) Kahn, B., et al.: *Rapid Methods for Estimating Fission Product Concentrations in Milk, Public Health Service Pub. No. 999-R-2.* Single free copies may be obtained from Public Inquiries Branch, PHS, U.S. Department of Health, Education, and Welfare, Washington 25, D.C.

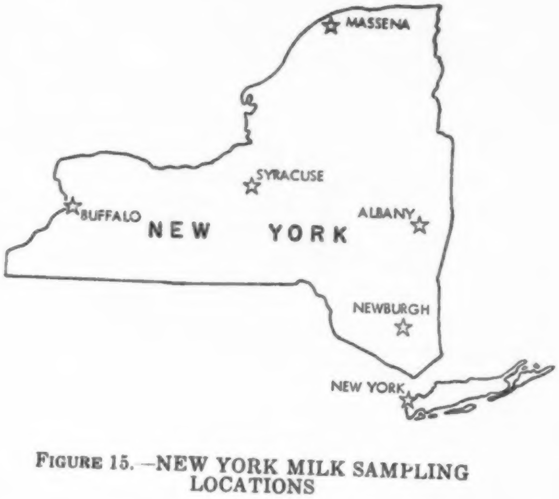

FIGURE 15.—NEW YORK MILK SAMPLING LOCATIONS

TABLE 8.—RADIONUCLIDES IN NEW YORK MILK, NOVEMBER-DECEMBER 1962

[Concentrations in pc/liter]

Sampling location	Strontium-89		Strontium-90		Iodine-131		Cesium-137	
	Nov.	Dec.	Nov.	Dec.	Nov.	Dec.	Nov.	Dec.
Albany	30 [a](4)	11 (4)	11 (4)	9 (4)	25 (25)	<20 (15)	65 (25)	62 (15)
Buffalo	30 (4)	13 (2)	11 (4)	8 (4)	<20 (6)	<20 (4)	62 (6)	83 (4)
Massena	35 (4)	15 (4)	12 (4)	12 (4)	<20 (4)	<20 (4)	117 (4)	107 (4)
Newburgh	51 (4)	17 (4)	10 (4)	8 (4)	43 (3)	<20 (4)	77 (5)	52 (4)
New York City	46 (5)	17 (4)	9 (5)	10 (4)	55 (14)	25 (9)	[b]—	—
Syracuse	21 (3)	12 (4)	7 (3)	6 (4)	<20 (3)	<20 (4)	44 (5)	64 (4)

[a] Numbers in parentheses indicate the number of samples upon which the monthly average is based.
[b] A dash indicates no sample or no analysis.

OREGON MILK NETWORK
November 1962–February 1963

Division of Sanitation and Engineering
Oregon State Board of Health

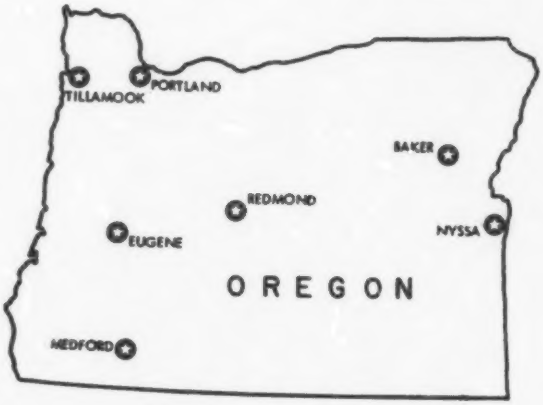

FIGURE 16.—OREGON PASTEURIZED MILK NET WORK SAMPLING LOCATIONS

Oregon's milk surveillance network was organized in March 1962, by the Oregon State Board of Health in cooperation with the Oregon State Department of Agriculture and Oregon State University. The half-gallon samples of packaged homogenized pasteurized milk are collected on a monthly basis by the Oregon Department of Agriculture and the City of Portland from eight milk districts throughout the State (see figure 16). Sampling on a weekly basis is performed when iodine-131 concentrations in milk exceed 100 pc/liter. The samples are forwarded to the Oregon State Board of Health radiation laboratory for iodine-131, cesium-137, and barium-140 analyses. The analyses are performed with a 3" x 3" sodium iodide scintillation crystal and a 512-channel pulse-height analyzer. All milk samples, after being gamma-scanned, are frozen and stored for future strontium-90 analyses.

Table 9 presents the Oregon milk surveillance data for November 1962 through February 1963. The Portland composite sample represents contributions from nearly all milk sheds in Oregon, including some in Washington State. Thus, it tends to represent a State averag [illegible] illamook has shown the highest concentrations with a maximum iodine-131 concentration for a single sample of 530 pc/liter on November 12, 1962. The frequency of sampling at Tillamook was temporarily increased to a weekly rate when concentrations exceeded 100 pc/liter. A review of the values obtained at Tillamook established that the iodine concentrations decreased at a rate corresponding to an 8-day half-life. This indicated an apparent single intrusion of fission products, rather than a continuous contribution from the atmosphere. The Tillamook and Coos Bay samples tend to be higher than other locations, probably due to the greater yearly precipitation along the Pacific Coast compared to the inland areas.

To maintain a check on the analytical procedures and instrument calibration, a split sample of the official U.S. Public Health Service pasteurized milk sample from Portland is obtained on a weekly basis for analysis. These data are compared to the Public Health Service data in figure 17.

TABLE 9.—RADIONUCLIDE CONCENTRATIONS IN OREGON MILK, NOVEMBER 1962–FEBRUARY 1963

[Average concentrations in pc/liter]

Sampling location	Number of samples analyzed				Iodine-131				Cesium-137				Barium-140			
	Nov.	Dec.	Jan.	Feb.	Nov.	Dec.	Jan.	Feb.	Nov.	Dec.	Jan.	Feb.	Nov.	Dec.	Jan.	Feb.
Baker	1	1	1	1	<15	30	<15	<15	45	50	40	45	<15	<15	<15	<15
Coos Bay	0	2	1	1	—	60	30	30	—	110	110	110	—	70	<15	<15
Eugene	1	1	1	1	50	15	<15	<15	45	50	45	65	<15	<15	<15	<15
Medford	1	1	1	1	40	<15	<15	<15	35	35	30	45	<15	<15	<15	<15
Nyssa	1	1	1	1	20	15	<15	<15	35	90	40	30	<15	<15	<15	<15
Portland (composite)	4	5	4	3	110	40	15	<15	90	75	60	70	40	<15	<15	<15
Portland (local producer)	4	5	4	3	40	15	15	<15	70	70	70	65	20	<15	<15	<15
Redmond	1	1	1	2	80	<15	15	<15	40	30	35	60	<15	<15	<15	<15
Tillamook	4	2	1	1	390	100	30	<15	245	155	115	80	220	60	<15	<15

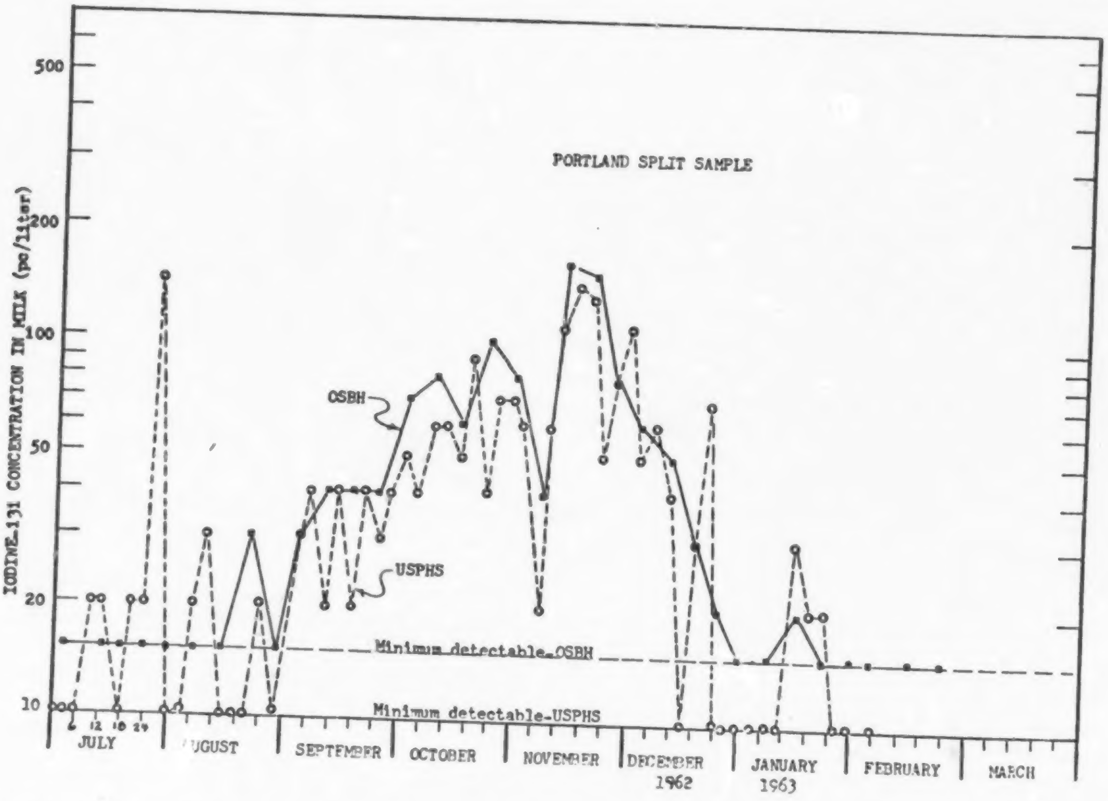

FIGURE 17.—COMPARISON OF PUBLIC HEALTH SERVICE AND OREGON STATE BOARD OF HEALTH MILK ANALYSES FOR PORTLAND

CANADIAN MILK NETWORK
December 1962

Radiation Protection Division
Department of National Health and Welfare, Ottawa, Canada

Dried Milk Products

Beginning in November 1955, radiochemical analyses of skim milk and buttermilk powders for strontium-90 concentrations were initiated by the Department of National Health and Welfare. Since April 1962, analyses for strontium-89 and cesium-137 have also been included.

Samples are collected through the cooperation of the Dairy Products Division of the Canadian Department of Agriculture, whose inspectors pick up four 1-pound samples of dried milk from each station (see figure 18) on a monthly schedule.

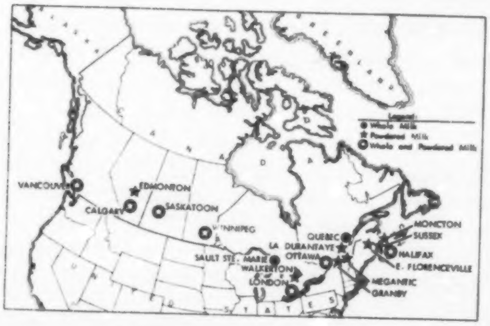
Legend:
Whole Milk
Powdered Milk
Whole and Powdered Milk
VANCOUVER
EDMONTON
CALGARY
SASKATOON
WINNIPEG
SAULT STE. MARIE
WALKERTON
LONDON
OTTAWA
LA DURANTAYE
QUEBEC
MONCTON
SUSSEX
HALIFAX
E. FLORENCEVILLE
MEGANTIC
GRANBY
UNITED STATES

FIGURE 18.—CANADIAN MILK SAMPLING STATIONS

No statistical plan is followed for sample collection. Because of uncertainties introduced by this method of sampling, the significance of differences between station-to-station and month-to-month results is not precisely known. However, it is possible to consider all results for a given period of time as being sufficiently random in selection to show any national trend when average values for such periods and all stations are plotted, as in figures 19 and 20.

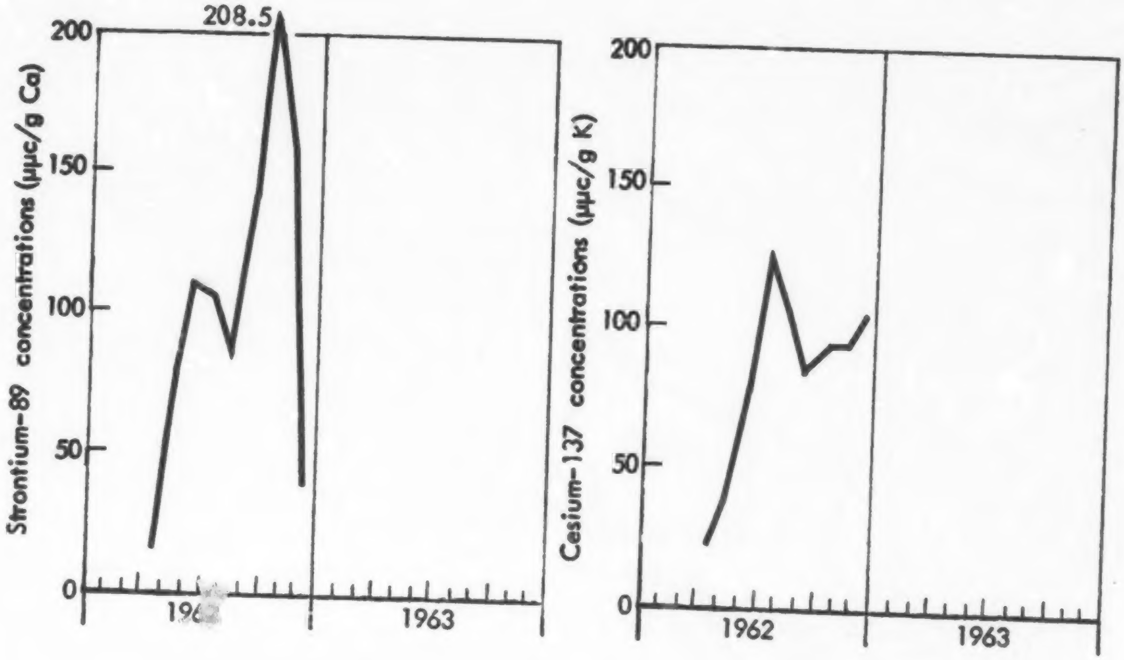

FIGURE 19.—AVERAGE STRONTIUM-89 AND CESIUM-137 CONCENTRATIONS IN MILK POWDER

A detailed discussion of the sampling and radiochemical procedures employed may be found in the Department's publications (*1*, *2*). Table 10 presents the results of measurements of strontium-89, strontium-90, and cesium-137 in Canadian dried milk powder for December 1962. These data were taken from the "Data from Radiation Protection Programs," dated February 1963, published by the Radiation Protection Division of the Department of National Health and Welfare.

TABLE 10.—RADIONUCLIDES IN CANADIAN DRIED MILK POWDER, DECEMBER 1962

Station	Strontium-89 (μμc/g Ca)	Strontium-90 (μμc/g Ca)	Cesium-137 (μμc/g K)
Arborg	—[a]	—	—
Calgary	86.8	40.8	90
E. Florenceville	—	—	—
Edmonton	62.9	25.3	87
Grunthal	28.3	17.0	58
Halifax	18.9	19.0	103
La Durantaye	24.5	39.6	162
Lawrenceville	19.7	25.5	118
London	17.9	10.4	58
Megantic	15.6	40.8	161
Moncton	17.4	31.5	140
Nicolet	19.2	21.2	78
Ottawa	23.6	20.0	—
Saskatoon	102.4	18.9	59
Sussex	77.8	59.8	131
Vancouver	52.1	25.2	115
Walkerton	20.8	11.8	68
Average	39.2	27.1	102

[a] Dash indicates no sample.

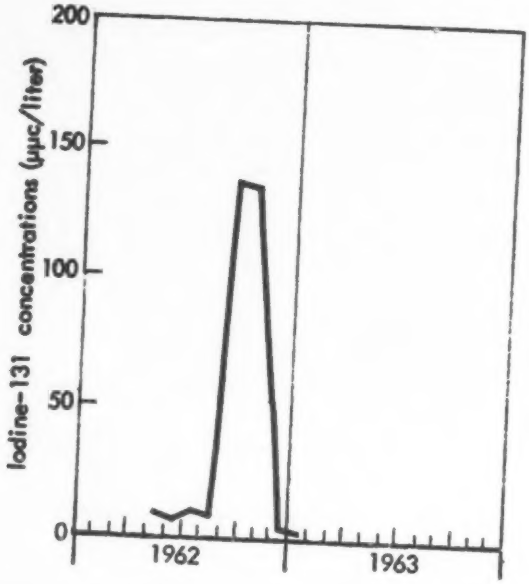

FIGURE 20.—IODINE-131 CONCENTRATIONS IN WHOLE MILK

During 1962, there has been almost a continual increase in the national average strontium-90 concentrations from the low of 6.9 μμc/g calcium in March to 32.7 μμc/g calcium in November (see figure 21). In December, the national average decreased to 27.1 μμc/g calcium. However, the national average for 1962 was 19.4 μμc/g calcium.

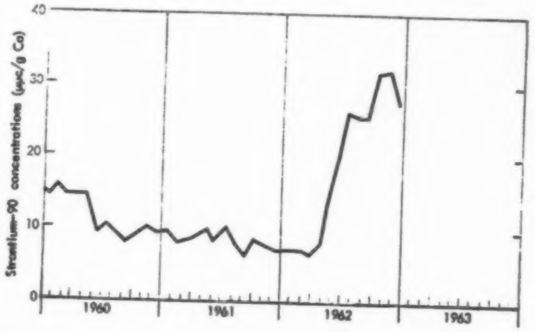

FIGURE 21.—AVERAGE STRONTIUM-90 CONCENTRATIONS IN CANADIAN DRIED MILK POWDER

The national average strontium-89 concentration in powdered milk dropped to 27.1 μμc/g calcium in December. As shown in figure 19 there is quite a pronounced peak in the national average strontium-89 concentrations in 1962.

For an approximate method to compare the Canadian powdered milk data in units of μμc/g calcium to other milk data in units of μμc/liter, it can be assumed that milk has approximately 1.2 g calcium/liter of liquid milk. Canadian powdered milk data may be compared to liquid milk data by multiplying the former values by 1.2.

Whole Milk

In April 1962, monitoring of liquid whole milk for iodine-131 was begun. Table 11 presents the December 1962 and January 1963 average concentrations of iodine-131 in liquid whole milk for nine cities. It may be noted that the national average which increased during the fall of 1962 has decreased to 7 μμc/liter in December 1962 and has remained low (3 μμc/liter) during January 1963 (see figure 20) indicating very little fresh fallout entering the milk.

It should be emphasized again that the interpretation of fallout data in relation to health is a complex problem. In comparing the values of the concentration levels in a particular medium

90

TABLE 11.—IODINE-131 IN CANADIAN LIQUID WHOLE MILK

[Concentrations in μμc/liter]

Station	December 1962	January 1963
Calgary	9 (12)[a]	5 (13)
Halifax	10 (10)	3 (12)
Ottawa	5 (10)	2 (13)
Quebec	7 (11)	4 (13)
Saskatoon	4 (10)	4 (13)
Sault Ste. Marie	8 (11)	3 (12)
Vancouver	8 (10)	2 (13)
Windson	12 (7)	5 (13)
Winnipeg	3 (12)	2 (13)
Average	7	3

[a] Numbers in parentheses indicate the number of samples on which the monthly average is based.

with the so-called Maximum Permissible Concentrations (MPC's) as established by the International Commission on Radiological Protection (*3*), it is necessary to keep in mind that the MPC values refer to conditions of continuous exposure over a lifetime. Therefore, the average levels over an extended period, such as one year, represent a better basis for comparison than do individual levels at any specific time.

REFERENCES

(*1*) Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada: *The Preliminary Report on the Measurements of Radioactive Strontium in Canadian Milk Powder Samples, CNHW (RPD-1)* (July 1958).

(*2*) Mar, Peter G.: *Outline of Procedure for the Radiochemical Analysis of Dried Milk Powders for Strontium and Yttrium, (RPD-5)*, Radiation Protection Division, Department of National Health and Welfare (June 1, 1960).

(*3*) Recommendations of the International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation*, Pergamon Press, New York (1959).

MEXICAN MILK NETWORK

November–December 1962

Radiological Protection Program of the National Commission of Nuclear Energy, Mexico

The Pasteurized Milk Monitoring Program of Mexico was established in March 1962 by the "Comision National de Energia Nuclear" through its Radiological Protection Program to provide a means for estimating the ingestion of strontium-90 from milk.

Milk has been analyzed from twelve cities distributed throughout Mexico. Since each city is supplied from a large number of sources, it has not been possible, to date, to apply a representative sampling method. However, samples from at least four main sources that supply large population groups were collected in each city.

The results presented in table 12 give an estimation of the strontium-90 content of the milk consumed in Mexico.

TABLE 12.—STRONTIUM-90 IN MEXICAN PASTEURIZED MILK, NOVEMBER-DECEMBER 1962

[Monthly averages]

Month (1962)	Sampling location	Calcium (g/liter)	Strontium-90 (μμc/liter)	Strontium-90 (μμc/g Ca)
November	México, D. F.[a]	1.07	2.9	2.7
	Puebla	1.13	1.5	1.4
	Poza Rica	1.15	1.1	1.0
December	México, D. F.	1.16	1.35	1.2
	Casas Grandes	1.10	2.6	2.4
	Tuxtla Gutierrez	1.12	1.0	1.0
	Villahermosa	1.38	4.1	3.0

[a] México City.

Twelve Month Sum of Daily Radionuclide Content of One Liter of Pasteurized Milk

Iodine-131: March 1962–February 1963
Strontium-89 and strontium-90:
February 1962–January 1963

Division of Radiological Health, Public Health Service

The guidance of the Federal Radiation Council (FRC) is given in terms of transient rates of intake of radioactive materials in micromicrocuries per day. The action ranges as proposed in FRC Report No. 2 are based on radiation doses considered acceptable for lifetime exposure from normal peacetime atomic industry operations (*1*). The Council recommends the use of a time period of one year as an appropriate interval for averaging exposures and emphasizes that the annual acceptable exposure dose is not a "danger point" which, if exceeded, requires protective measures (*1, 2, 3,*).

To facilitate comparison of the concentrations of certain radionuclides in milk with the Radiation Protection Guides, tables 1 and 2 below furnish a means towards estimating the contribution of milk to the total dietary intake of iodine-131, strontium-89, and strontium-90. The tables are developed from the PHS Pasteurized Milk Network monthly averages of the radionuclides. They present index values which are the estimated sum of the daily amounts of a radionuclide in one liter of milk for a 12-month period.

The tables show 12-month index values for each of the Network's 62 sampling locations. Due to the longer time required for strontium-89 and strontium-90 analysis, these 12-month index values are for the year beginning one month earlier than the iodine-131 values. The columns of monthly index values in each table are used to compute the net change as the yearly index values are advanced by one month. The following column shows this new 12-month index value. In addition, the second column in table 1 gives the iodine-131 February 1963 concentration averages.

The data in tables 1 and 2 are calculated as follows: (a) results from all samples collected in each week (Sunday through Saturday) are averaged, (b) the weekly averages for all weeks ending within a given month are averaged and an average for the month is obtained, and (c) the monthly radionuclide index value is determined by multiplying the average for the month by the number of days in the month. The number of days in the month will be either 28 or 35, corresponding to the complete calendar weeks used for any month. Procedures exemplified by (a) and (b) above minimize the effect of any one day's sample results on the average for the month, particularly for a short-lived radionuclide such as iodine-131. Yearly index values are obtained by the following procedure. In column (A) are the twelve-month index values for the period indicated. In columns (B) and (C) are the monthly index values for the periods indicated. The values in column (D) are obtained by adding the values in column (B) to those in column (A) and subtracting those in (C).

For a number of reasons it is desirable to have a standard quantity of milk to use in the development of index values for the different radionuclides. When one is concerned with strontium, 1 liter is a suitable quantity, as this amount of milk supplies approximately 1 gram of calcium, the amount used by the Federal Radiation Council in deriving the intake guidance for strontium. When one is concerned with iodine-131, the critical age group is the young infant. Available information suggests that the average milk consumption of infants in the 6-18 month group is not more than 1 liter per day. Thus the index value based on 1 liter of milk, though not directly an average intake value, is probably the most useful index for estimating total intake.

REFERENCES

(*1*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2,* Superintendent of Documents, U. S. Government Printing Office (September 1961), price 20 cents.

(*2*) Chadwick, Donald R., and Conrad P. Straub: Considerations in Establishing Radiation Protection standards for Radioactivity in the Environment, *Radiological Health Data,* *3*:159-65, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (May 1962).

(*3*) Public Health Service: Special Report, *Radiological Health Data,* *3*:ii-iii, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (September 1962).

TABLE 1.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF IODINE-131 IN ONE LITER OF MILK

[μμc day/liter][a]

Sampling locations		Feb. 1963 iodine-131 averages (μμc/liter)	Iodine-131 index value			
			Feb 1962–Jan 1963 (A)	Feb 1963 (B)	Jan 27, 1963–Feb 23, 1963 (C)	Mar 1962–Feb 1963 (D)
Ala:	Montgomery	<10	6,590	140	140	6,590
Alaska:	Palmer	<10	38,220	140	140	38,220
Ariz:	Phoenix	<10	4,270	140	140	4,270
Ark:	Little Rock	20	14,250	140	560	14,670
Calif:	Sacramento	<10	5,050	140	140	5,050
	San Francisco	<10	4,940	140	140	4,940
Colo:	Denver	<10	5,860	280	140	5,720
Conn:	Hartford	<10	7,670	140	140	7,670
Del:	Wilmington	10	11,730	140	280	11,870
D. C:	Washington	<10	8,440	140	140	8,440
Fla:	Tampa	20	6,240	140	560	6,660
Ga:	Atlanta	10	8,900	140	280	9,040
Hawaii:	Honolulu	20	4,830	140	560	5,250
Idaho:	Idaho Falls	<10	9,660	560	140	9,240
Ill:	Chicago	<10	13,690	140	140	13,690
Ind:	Indianapolis	<10	12,010	140	140	12,010
Iowa:	Des Moines	<10	21,840	140	140	21,840
Kans:	Wichita	<10	21,740	140	140	21,740
Ky:	Louisville	<10	10,540	140	140	10,540
La:	New Orleans	30	8,900	140	840	9,600
Maine:	Portland	<10	8,160	140	140	8,160
Md:	Baltimore	<10	8,690	140	140	8,690
Mass:	Boston	<10	7,950	140	140	7,950
Mich:	Detroit	<10	12,820	140	140	12,820
	Grand Rapids	10	9,420	140	280	9,560
Minn:	Minneapolis	<10	16,170	140	140	16,170
Miss:	Jackson	20	9,110	140	560	9,530
Mo:	Kansas City	<10	30,380	280	140	30,240
	St. Louis	<10	12,530	140	140	12,530
Mont:	Helena	10	14,910	560	280	14,630
Nebr:	Omaha	<10	19,530	280	140	19,390
Nev:	Las Vegas	<10	[b]4,100	[c]—	140	[b]4,240
N. H:	Manchester	20	7,290	140	560	7,710
N. J:	Trenton	<10	7,990	140	140	7,990
N. Mex:	Albuquerque	<10	7,460	560	140	7,040
N. Y:	Buffalo	<10	8,720	140	140	8,720
	New York	<10	11,660	140	140	11,660
	Syracuse	<10	9,980	140	140	9,980
N. C:	Charlotte	<10	8,370	140	140	8,370
N. Dak:	Minot	<10	14,910	140	140	14,910
Ohio:	Cincinnati	10	14,460	140	280	14,600
	Cleveland	<10	11,100	140	140	11,100
Okla:	Oklahoma City	10	18,240	140	280	18,380
Ore:	Portland	<10	9,770	140	140	9,770
Pa:	Philadelphia	<10	10,820	140	140	10,820
	Pittsburgh	10	14,670	140	280	14,810
P. R:	San Juan	30	[d]5,260	140	840	[d]5,960
R. I:	Providence	10	8,440	140	280	8,580
S. C:	Charleston	20	6,590	140	560	7,010
S. Dak:	Rapid City	10	14,530	140	280	14,670
Tenn:	Chattanooga	<10	7,850	140	140	7,850
	Memphis	<10	10,050	140	140	10,050
Tex:	Austin	<10	11,040	140	140	11,040
	Dallas	20	18,420	140	560	18,840
Utah:	Salt Lake City	10	31,920	280	280	31,920
Vt:	Burlington	<10	8,380	140	140	8,380
Va:	Norfolk	<10	6,410	140	140	6,410
Wash:	Seattle	<10	9,940	140	140	9,940
	Spokane	10	21,770	140	280	21,910
W. Va:	Charleston	10	6,830	140	280	6,970
Wis:	Milwaukee	10	14,320	140	280	14,460
Wyo:	Laramie	<10	19,850	280	140	19,710

[a] The data in this table are index values, not to be interpreted as consumption or total intake values. Annual iodine-131 intake per person may be calculated from an index value in this table by applying the appropriate factor representing average individual daily milk consumption for any selected group under consideration.

Example: 12-month I^{131} index × milk consumption factor = 12-month I^{131} intake
(μμc day/liter) (liter/day/person) (μμc/person)

[b] Station included in milk network in July 1962. The sums in column A and D are therefore for 7 and 8 months, respectively.

[c] A dash indicates no analysis.

[d] No sample was received in November 1962. These sums are therefore for 11 months.

TABLE 2.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF STRONTIUM-89 AND STRONTIUM-90 IN ONE LITER OF MILK

Sampling locations		Strontium-89 index values (μμc day/liter)[a]				Strontium-90 index values (μμc day/liter)[a]			
		Jan. 1962-Dec. 1962 (A)	Jan. 1962 (B)	Dec. 30, 1962-Jan. 26, 1963 (C)	Feb. 1962-Jan. 1963 (D)	Jan. 1962-Dec. 1962 (A)	Jan. 1962 (B)	Dec. 30, 1962-Jan. 26, 1963 (C)	Feb. 1962-Jan. 1963 (D)
Ala:	Montgomery	21,385	70	2,240	23,555	5,324	270	420	5,474
Alaska:	Palmer	18,665	270	700	19,095	3,607	135	336	3,808
Ariz:	Phoenix	6,570	810	700	6,460	1,145	81	112	1,176
Ark:	Little Rock	48,215	1,350	3,500	50,365	10,661	567	812	10,906
Calif:	Sacramento	6,905	270	420	7,055	1,363	54	84	1,393
	San Francisco	11,610	270	1,680	13,020	1,895	54	140	1,981
Colo:	Denver	10,435	405	280	10,310	3,529	162	364	3,731
Conn:	Hartford	8,000	70	140	8,070	3,861	270	336	3,927
Del:	Wilmington	12,985	70	280	13,195	4,799	270	448	4,977
D. C:	Washington	12,550	70	280	12,760	5,164	243	364	5,285
Fla:	Tampa	8,980	405	840	9,415	3,459	162	336	3,633
Ga:	Atlanta	30,580	2,160	2,380	30,800	6,401	297	504	6,608
Hawaii:	Honolulu	9,870	945	1,120	10,045	1,858	108	168	1,918
Idaho:	Idaho Falls	8,730	135	280	8,875	3,230	108	364	3,486
Ill:	Chicago	10,800	70	70	10,800	3,886	162	392	4,116
Ind:	Indianapolis	13,720	70	280	13,930	4,772	243	420	4,949
Iowa:	Des Moines	23,670	270	560	23,960	4,461	135	392	4,718
Kans:	Wichita	18,185	405	840	18,620	4,096	162	336	4,270
Ky:	Louisville	27,640	270	840	28,210	7,030	324	588	7,294
La:	New Orleans	61,790	8,100	4,480	58,170	10,854	648	840	11,046
Maine:	Portland	10,800	70	70	10,800	4,982	243	560	5,299
Md:	Baltimore	11,815	70	70	11,815	5,404	280	420	5,544
Mass:	Boston	11,290	70	140	11,360	5,731	243	504	5,992
Mich:	Detroit	9,785	70	140	9,855	3,956	162	448	4,242
	Grand Rapids	8,350	70	280	8,560	3,590	216	420	3,794
Minn:	Minneapolis	20,135	270	420	20,285	5,818	162	560	6,216
Miss:	Jackson	55,930	5,670	4,760	55,020	8,740	648	700	8,792
Mo:	Kansas City	30,505	405	840	30,940	5,145	189	448	5,404
	St. Louis	19,100	270	560	19,390	4,843	216	336	4,963
Mont:	Helena	16,025	135	700	16,590	4,203	108	392	4,487
Nebr:	Omaha	20,740	405	700	21,035	4,576	135	448	4,889
Nev:	Las Vegas	[b]4,760	—	280	[b]5,040	[b]994	—	168	[b]1,162
N. H:	Manchester	10,345	70	140	10,415	5,072	270	560	5,362
N. J:	Trenton	9,925	70	70	9,925	3,962	216	392	4,158
N. Mex:	Albuquerque	6,165	540	560	6,185	1,611	162	168	1,617
N. Y:	Buffalo	8,770	70	280	8,980	4,105	297	420	4,223
	New York	10,555	70	70	10,555	4,951	324	448	5,075
	Syracuse	9,555	70	70	9,555	3,942	162	448	4,228
N. C:	Charlotte	20,360	270	700	20,790	6,856	297	700	7,259
N. Dak:	Minot	16,370	135	420	16,655	6,699	189	784	7,294
Ohio:	Cincinnati	17,355	135	560	17,780	5,247	270	504	5,481
	Cleveland	10,660	70	140	10,730	4,234	216	420	4,438
Okla:	Oklahoma City	25,440	1,080	1,820	26,180	5,997	243	476	6,230
Ore:	Portland	29,605	1,080	1,960	30,485	4,879	189	336	5,026
Pa:	Philadelphia	10,205	70	280	10,415	4,493	216	504	4,781
	Pittsburgh	12,215	70	70	12,215	5,546	324	532	5,754
P. R:	San Juan	[b]23,920	3,375	4,200	[b]24,745	[b]3,329	270	336	[b]3,395
R. I:	Providence	8,980	70	280	9,190	4,521	216	392	4,697
S. C:	Charleston	24,720	1,620	1,680	24,780	6,832	378	560	7,014
S. Dak:	Rapid City	19,785	270	700	20,215	5,482	162	420	5,740
Tenn:	Chattanooga	42,435	1,485	1,960	42,910	7,851	270	616	8,197
	Memphis	38,185	2,835	2,660	38,010	7,587	405	616	7,798
Tex:	Austin	10,235	540	1,960	11,655	2,558	108	252	2,702
	Dallas	27,715	1,080	3,640	30,275	5,305	216	504	5,593
Utah:	Salt Lake City	10,935	135	420	11,220	3,166	135	336	3,367
Vt:	Burlington	10,970	135	140	10,975	4,066	216	448	4,298
Va:	Norfolk	17,105	270	560	17,395	6,345	297	504	6,552
Wash:	Seattle	21,505	540	980	21,945	5,433	162	252	5,523
	Spokane	13,105	135	560	13,530	4,453	162	364	4,655
W. Va:	Charleston	20,785	135	420	21,070	6,591	270	532	6,853
Wis:	Milwaukee	8,245	70	280	8,455	3,046	162	252	3,136
Wyo:	Laramie	18,740	135	560	19,165	3,552	108	420	3,864

[a] The data in this table are index values, not to be interpreted as consumption or total intake values. Annual strontium-89 or strontium-90 intake per person may be calculated from an index value in this table by applying the appropriate factor representing average daily milk consumption for any selected group under consideration.

Example: 12-month index value × milk consumption factor = 12-month intake
(μμc day/liter) (liter/day/person) (μμc/person)

[b] Station included in milk network in July 1962. The sums in columns A and D are for 6 and 7 months, respectively.

[c] A dash indicates no analysis.

[d] No sample was received for November 1962. These sums are therefore for 11 months.

SECTION III.—WATER

Radioactivity in Raw Surface Waters

NATIONAL WATER QUALITY NETWORK
November 1962

Division of Water Supply and Pollution Control, Public Health Service

Radioactivity levels in the surface waters of the United States have been under surveillance by the Public Health Service through the National Water Quality Network since this nationwide sampling program was initiated in 1957. Beginning with the the establishment of 50 sampling points, this network has been expanded as of March 1963, to 125 stations (figure 1), which are operated jointly with State, Federal and local agencies and industry. The stations are located on the major waterways used for public water supplies, propagation of fish and wildlife, and recreational, agricultural, and industrial purposes. At these stations, samples are taken weekly, monthly, or continuously, depending on the type of analysis to be performed and on the water quality. The samples are then analyzed for plankton population, organic chemicals, chemical, biological, and physical quality, and radioactivity (*1,3*).

Radioactivity associated with dissolved solids provides a rough measure of levels which may be found in treated water, since nearly all of the suspended matter is removed by treatment processes (*4*). It has been observed that in water the natural environmental beta activity is usually several times that of the natural environmental alpha activity. Nuclear installations may contribute additional alpha or beta activity whereas fallout contributes primarily additional activity. Gross alpha and beta measurements are made on both suspended and dissolved solids (strontium-90 on the total solids only) in raw surface water samples according to established procedures (*5, 6*).

For the first two years of the network's operations, beta determinations were made on weekly samples, and alpha determinations were generally made on composites of more than one weekly sample. From January 1960 to September 1961, alpha and beta determinations were generally made once a month on weekly composited samples.

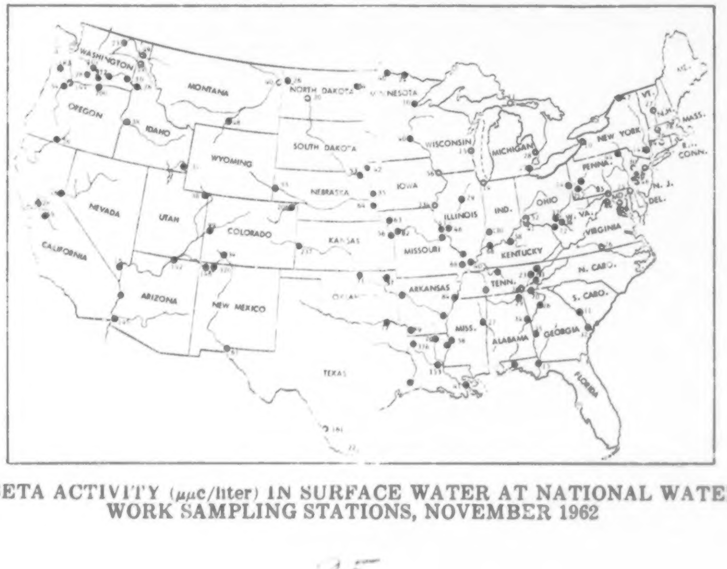
WASHINGTON
MONTANA
NORTH DAKOTA
MINNESOTA
OREGON
IDAHO
WYOMING
SOUTH DAKOTA
WISCONSIN
MICHIGAN
NEW YORK
VT.
N.H.
MASS.
CONN.
R.I.
PENNA.
N. J.
DEL.
NEBRASKA
IOWA
NEVADA
UTAH
COLORADO
KANSAS
ILLINOIS
IND.
OHIO
VA.
VIRGINIA
MISSOURI
KENTUCKY
CALIFORNIA
N. CARO.
TENN.
ARKANSAS
ARIZONA
NEW MEXICO
S. CARO.
MISS.
ALABAMA
GEORGIA
TEXAS
FLORIDA

FIGURE 1.—TOTAL BETA ACTIVITY (μμc/liter) IN SURFACE WATER AT NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS, NOVEMBER 1962

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, NOVEMBER 1962

[Average concentrations in pc/liter]

Station	November 1962					
	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River: Pittsburgh, Pa	—	—	—	—	—	—
Animas River: Cedar Hill, N. Mex	283	37	320	9	3	12
Apalachicola River: Chattahoochie, Fla	3	12	15	0	0	0
Arkansas River:						
Coolidge, Kans	91	146	237	2	39	41
Ponca City, Okla	32	39	71	1	3	4
Bear River: Preston, Idaho	9	25	34	<1	2	2
Bighorn River: Hardin, Mont	16	32	48	2	6	8
Sioux River: Sioux Falls, S. Dak	11	42	53	—	—	—
Chattahoochie River:						
Atlanta, Ga	9	17	26	1	0	1
Columbus, Ga	17	18	35	1	0	1
Lanett, Ala	22	12	34	1	0	1
Chena Slough: Fairbanks, Alaska	10	21	31	0	1	1
Clear Water River: Lewiston, Idaho	12	14	26	0	0	0
Clinch River:						
Kingston, Tenn	—	—	—	—	—	—
Clinton, Tenn	5	18	23	0	<1	<1
Colorado River:						
Loma, Colo	59	40	99	2	8	10
Page, Ariz	108	34	142	21	7	28
Boulder City, Nev	0	15	15	0	9	9
Parker Dam, Calif.-Ariz	—	—	—	—	—	—
Yuma, Ariz	37	109	146	0	10	10
Columbia, River:						
Northport, Wash	5	18	23	0	<1	<1
Wenatchee, Wash	0	10	10	1	2	3
Pasco, Wash	28	544	572	0	1	1
McNary Dam, Ore	17	183	200	0	1	1
Bonneville, Ore	22	122	144	0	1	1
Clatskanie, Ore	101	81	182	0	0	0
Connecticut River:						
Wilder, Vt	8	19	27	0	<1	<1
Northfield, Mass	7	19	26	0	0	0
Enfield Dam, Conn	8	16	24	0	<1	<1
Delaware River:						
Martins Creek, Pa	7	23	30	0	0	0
Trenton, N. J.	12	22	34	0	0	0
Philadelphia, Pa	16	24	40	0	0	0
Escambia River: Century, Fla	—	—	—	—	—	—
Great Lakes:						
Duluth, Minn	5	5	10	0	0	0
Sault Ste. Marie, Mich	3	8	11	0	0	0
Milwaukee, Wis	1	14	15	0	0	0
Gary, Ind	1	13	14	0	0	0
Port Huron, Mich	6	22	28	0	0	0
Detroit, Mich	3	19	22	0	0	0
Buffalo, N. Y	4	6	10	0	0	0
Green River: Dutch John, Utah	27	29	56	0	2	2
Hudson River: Poughkeepsie, N. Y.	12	135	147	1	0	1
Illinois River:						
Peoria, Ill	5	24	29	1	1	2
Grafton, Ill	24	29	53	1	0	1
Kanawha River: Winfield Dam, W. Va	19	17	36	1	0	1
Klamath River: Keno, Ore	8	18	26	0	0	0
Little Miami River: Cincinnati, Ohio	14	38	52	0	1	1
Merrimack River: Lowell, Mass	9	67	76	0	0	0
Mississippi River:						
St. Paul, Minn	9	31	40	0	0	0
Dubuque, Iowa	27	29	56	0	0	0
Burlington, Iowa	310	24	334	0	0	0
E. St. Louis, Ill	9	37	46	0	1	1
Cape Girardeau, Mo	20	48	68	1	2	3
W. Memphis, Ark	56	28	84	0	2	2
Delta, La	—	—	—	—	—	—
New Orleans, La	10	31	41	1	3	4
Vicksburg, Miss	25	33	58	2	1	3
Missouri River:						
Williston, N. Dak	9	17	26	1	4	5
Bismarck, N. Dak	2	18	20	1	4	5
Yankton, S. Dak	3	50	53	0	4	4
Omaha, Nebr	13	22	35	2	4	6
St. Joseph, Mo	18	45	63	3	10	13
Kansas City, Kans	26	30	56	2	7	9
St. Louis, Mo	—	—	—	—	—	—
Missouri City, Mo	38	44	82	7	9	16
Monongahela River: Pittsburgh, Pa	3	22	25	0	1	1
North Platte River: Henry, Nebr	10	45	55	1	23	24
Ohio River:						
E. Liverpool, Ohio	1	13	14	0	0	0
Addison, Ohio	6	26	32	<1	1	1
Huntington, W. Va	41	31	72	2	0	2
Cincinnati, Ohio	15	26	41	1	1	2
Louisville, Ky	34	24	58	1	0	1
Evansville, Ind	34	34	68	1	0	1
Cairo, Ill	21	19	40	6	1	7
Ouchita River: Bastrop, La	4	16	20	0	1	1
Pend Oreille River: Albeni Falls Dam, Idaho	13	36	49	0	<1	<1
Platte River: Plattsmouth, Nebr	23	41	64	2	6	8

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, NOVEMBER 1962—Continued

[Average concentrations in pc/liter]

Station	November 1962					
	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Potomac River:						
Williamsport, Md	20	15	35	0	0	0
Great Falls, Md	29	80	109	1	0	1
Rainy River:						
Baudette, Minn	9	31	40	0	0	0
International Fls, Minn	4	20	24	<1	0	<1
Red River: Grand Forks, N. Dak	1	33	34	—	—	—
Red River, South:						
Denison, Tex	36	41	77	0	1	1
Index, Ark	43	46	89	1	1	2
Alexandria, La	122	31	153	4	0	4
Bossier City, La	297	79	376	7	8	15
Rio Grande River:						
Alamaso, Colo	16	18	34	1	0	1
El Paso, Tex	22	39	61	1	6	7
Laredo, Tex	110	51	161	—	—	—
Brownsville, Tex	6	16	22	1	5	6
Roanoke River: John H. Kerr Resr. & Dam, Va	7	19	26	0	0	0
Sabine River: Rubliff, Tex	—	—	—	—	—	—
Sacramento River:						
Greens Landing, Courtland, Calif	13	15	28	1	1	2
San Joaquin River: Vernalis, Calif	31	24	55	1	3	4
San Juan River: Shiprock, N. Mex	95	51	146	11	6	17
St. Lawrence River: Massena, N. Y	24	23	47	0	0	0
Schuylkill River, Philadelphia, Pa	26	20	46	1	0	1
Savanah River:						
North Augusta, Ga	3	8	11	0	0	0
Port Wentworth, Ga	7	25	32	0	0	0
Shenandoah River: Berryville, Va	14	30	44	<1	1	1
Ship Creek: Anchorage, Alaska	0	7	7	0	0	0
Snake River:						
Ice Harbor Dam, Wash	7	23	30	<1	2	2
Wawawai, Wash	—	—	—	—	—	—
Payette, Idaho	9	29	38	<1	2	2
South Platte River: Julesburg, Colo	28	178	206	2	28	30
Spokane River: Post Falls, Idaho	12	12	24	0	0	0
Susquehanna River:						
Sayre, Pa	24	20	44	0	0	0
Conowingo, Md	10	15	25	0	0	0
Tennessee River:						
Chattanooga, Tenn	16	54	70	0	0	0
Bridgeport, Ala	2	27	29	0	1	1
Pickwick Landing, Tenn	2	36	38	0	0	0
Lenoir City, Tenn	9	24	33	<1	0	<1
Tombigbee River: Columbus, Miss	12	15	27	0	<1	<1
Truckee River: Farad, Calif	5	11	16	—	—	—
Verdigris River: Nowata, Okla	10	47	57	<1	2	2
Wabash River: New Harmony, Ind	93	37	130	5	1	6
Willamette River: Portland, Ore	39	15	54	<1	0	<1
Yakima River: Richland, Wash	3	25	28	0	1	1
Yellowstone River: Sidney, Mont	5	35	40	0	3	3

Beginning in September 1961, alpha determinations have been made on one sample each month, and beta determinations have generally been made on weekly samples. For the first operating year of each new station, sampling, and alpha and beta analysis are done weekly.

If at any time activity significantly greater than the normal environmental levels has been noted, the rate of sampling and analysis has been increased to at least one every week. Since January 1959, a portion of each sample from all stations in the network has been composited into a three-month station sample for measurement of strontium-90 (*7*). Because strontium-90 analyses are done quarterly, the results will be published on this basis.

Table 1 presents the results of the alpha and beta analyses on raw surface water in the United States for November 1962. These data are preliminary; reanalysis of some samples may be made and additional analyses, not completed at the time of the report, may become available. For final data one should consult reference (*8*).

Quarterly strontium-90 results for the past year are shown in table 2. These data have been confirmed.

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the total beta activity in suspended-plus-dissolved solids in raw water collected at that station.

REFERENCES

(*1*) Public Health Service: National Water Quality Control Network, *Fallout from Nuclear Weapons Tests*, *1*:167-9, Hearings before the Special Subcommittee on Radiation of the Committee on Atomic Energy, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (May 1959), price $2.75.

(*2*) Division of Water Supply and Pollution Control, Public

TABLE 2.—QUARTERLY STATION AVERAGE CONCENTRATIONS OF STRONTIUM-90 IN RAW SURFACE WATERS, JULY 1961–JUNE 1962

[Concentrations in pc/liter]

Station	Third quarter 1961	Fourth quarter 1961	First quarter 1962	Second quarter 1962
Allegheny River: Pittsburgh, Pa	0.3	0.6	1.7	1.2
Animas River, Cedar Hill, N. Mex	0.3	0.9	0.8	1.0
Apalachicola River:				
Chattahoochie, Fla	0.4	0.5	*0.9	0.9
Arkansas River:				
Coolidge, Kans	2.3	1.0	0.6	3.9
Ponca City, Okla	—	0.6	1.3	3.0
Pendelton Ferry, Ark	—	0.5	1.3	—
Bighorn River: Hardin, Mont	—	—	*1.5	6.4
Big Sioux River:				
Sioux Falls, S. Dak	0.4	1.2	2.0	5.9
Chattahoochie River:				
Atlanta, Ga	—	0.3	0.5	0.8
Columbus, Ga	—	0.1	0.6	—
Chena Slough: Fairbanks, Alaska	—	—	—	1.4
Clear Water River:				
Lewiston, Idaho	—	0.3	0.5	*0.4
Clinch River: Kingston, Tenn	—	—	—	1.7
Colorado River:				
Loma, Colo	—	0.8	1.2	1.5
Page, Ariz	—	1.9	1.5	4.9
Boulder City, Nev	1.0	1.8	1.3	2.0
Parker Dam, Calif-Ariz	—	1.5	1.0	1.7
Yuma, Ariz	—	0.7	0.6	1.0
Columbia River:				
Northport, Wash	—	—	—	0.6
Wenatchee, Wash	—	0.7	0.9	0.8
Pasca, Wash	1.1	0.7	1.1	0.8
McNary Dam, Ore	1.2	0.6	0.9	0.7
Bonneville Dam, Ore	*0.6	0.8	1.1	1.6
Clatskanie, Ore	—	0.6	0.7	0.7
Connecticut River:				
Wilder, Vt	—	3.7	0.8	0.8
Northfield, Mass	0.4	0.4	0.6	1.0
Cumberland River:				
Clarksville, Tenn	0.4	0.9	—	—
Delaware River:				
Martins Creek, Pa	—	0.5	0.7	1.1
Trenton, N. J	—	0.7	1.0	1.6
Philadelphia, Pa	—	—	*0.7	1.3
Escambia River, Century, Fla	*0.9	0.5	0.4	1.1
Great Lakes:				
Duluth, Minn	—	0.1	0.8	0.5
Sault Ste. Marie, Mich	—	0.5	0.5	0.6
Milwaukee, Wis	—	0.8	0.5	0.7
Gary, Ind	0.2	0.1	0.9	0.7
Port Huron, Mich	0.4	0.8	0.8	1.3
Detroit, Mich	*0.6	0.4	1.1	1.2
Buffalo, N. Y	—	0.8	1.0	1.1
Hudson River: Poughkeepsie, N. Y	0.2	2.5	1.1	1.7
Illinois River:				
Peoria, Ill	0.4	0.7	1.0	1.7
Grafton, Ill	—	0.6	2.5	2.4
Kanawha River:				
Winfield Dam, W. Va	—	0.5	0.4	0.8
Klamath River: Keno, Ore	—	1.2	1.1	1.8
Little Miami River:				
Cincinnati, Ohio	1.1	0.6	1.3	2.9
Merrimack River: Lowell, Mass	*0.7	—	—	—
Mississippi River:				
St. Paul, Minn	0.9	0.6	1.3	3.9
Dubuque, Iowa	—	0.8	0.7	2.9
Burlington, Iowa	0.6	1.9	1.0	2.0
E. St. Louis, Ill	—	0.9	1.2	2.2
Cape Girardeau, Mo	0.8	1.0	1.4	2.8
W. Memphis, Ark	—	1.1	1.5	2.7
Delta, La	*0.4	1.8	1.0	1.9
New Orleans, La	—	0.7	1.4	2.3
Vicksburg, Miss	—	0.7	2.0	3.1
Missouri River:				
Williston, N. Dak	—	1.2	1.4	1.1
Bismarck, N. Dak	—	1.1	1.4	1.9
Yankton, S. Dak	0.6	2.5	0.7	2.3
Omaha, Nebr	—	0.7	1.0	4.2
St. Joseph, Mo	—	0.5	1.1	3.0
Kansas City, Kans	—	0.9	0.5	1.8
Missouri City, Mo	—	—	1.5	2.8
St. Louis, Mo	1.4	2.1	1.3	2.7
Monongahela River:				
Pittsburgh, Pa	0.4	1.3	0.7	0.9
North Platte River: Henry, Nebr	—	1.3	0.5	2.2
Ohio River:				
E. Liverpool, Ohio	0.4	—	1.2	1.5
Huntington, W. Va	—	1.0	0.6	1.9
Cincinnati, Ohio	—	0.6	1.2	1.9
Louisville, Ky	0.4	0.7	1.3	1.3
Evansville, Ind	—	0.9	1.0	1.4
Cairo, Ill	1.1	—	1.4	2.0
Ouachita River: Bastrop, La	—	0.7	2.0	1.6
Pend Oreille River:				
Albeni Falls Dam, Idaho	—	—	—	1.6
Platte River: Plattsmouth, Nebr	—	0.4	2.2	6.0
Potomac River:				
Williamsport, Md	—	0.9	0.5	0.9
Great Falls, Md	—	0.6	1.1	2.2
Rainy River:				
International Fls., Minn	—	0.3	2.4	1.4
Baudette, Minn	—	—	1.4	2.4
Red River, North:				
Grand Forks, N. Dak	—	1.1	—	—
Red River, South:				
Denison, Tex	—	2.2	2.2	2.2
Index, Ark	—	1.7	2.1	6.1
Alexandria	1.0	2.7	1.1	2.5
Rio Grande River:				
Alamosa, Colo	*0.4	—	*0.6	1.1
El Paso, Tex	—	—	*0.5	1.2
Laredo, Tex	—	0.6	0.4	2.0
Brownsville, Tex	—	0.6	0.9	1.2
Roanoke River:				
John H. Kerr Resr. & Dam, Va	—	0.6	0.6	2.5
Sabine River: Ruliff, Tex	—	0.7	1.3	1.7
Sacramento River: Greens Landing, Courtland, Calif	—	—	—	0.9
San Juan River:				
Shiprock, N. Mex	—	1.3	1.9	1.0
St. Lawrence River:				
Massena, N. Y	—	1.6	0.8	1.2
Savanah River:				
North Augusta, S. C	—	—	0.8	1.0
Port Wentworth, Ga	0.4	0.6	0.9	1.9
Schuylkill River: Philadelphia, Pa	—	—	*0.6	1.5
Shenandoah River: Berryville, Va	—	0.2	0.4	0.9
Ship Creek: Anchorage, Alaska	—	—	—	*0.2
Snake River:				
Wawawai, Wash	0.3	0.2	0.9	0.6
Ice Harbor Dam, Wash	—	—	—	0.9
Payette, Idaho	—	2.5	0.3	0.6
South Platte River:				
Julesburg, Colo	.07	1.2	0.8	1.7
Spokane River: Post Falls, Idaho	—	—	—	0.7
Susquehanna River:				
Sayre, Pa	0.3	0.2	0.9	1.2
Conowingo, Md	0.3	0.9	0.5	1.0
Tennessee River:				
Chattanooga, Tenn	0.6	0.5	0.6	1.6
Bridgeport, Ala	0.7	1.5	2.0	2.0
Pickwick Landing, Tenn	—	0.4	1.3	1.7
Lenoir City, Tenn	—	—	1.2	1.1
Tombigbee River: Columbus, Miss	—	0.2	0.9	1.4
Truckee River: Farad, Calif	—	0.1	0.8	0.9
Verdigris River: Nowata, Okla	—	—	—	3.1
Wabash River: New Harmony, Ind	—	—	1.3	4.7
Yakima River: Richland, Wash	0.4	0.7	0.6	0.4
Yellowstone River: Sidney, Mont	—	1.2	1.3	30

* Six months composite—added period required to obtain sufficient sample for analysis.

Health Service: *National Water Quality Network Annual Compilation of Data*, PHS Publication No. 663, 1960 Edition, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

(*3*) Setter, L. R., and S. L. Baker: Radioactivity of Surface Waters in the United States, *Radiological Health Data, 1*:20-31 (October 1960).

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NORTH CAROLINA SURFACE WATER[1]
June 1958–December 1961

Sanitary Engineering Division
North Carolina State Board of Health[2]

The greater use of radioactive materials within the State of North Carolina presents an ever increasing concern to the State Board of Health and water works officials responsible for water quality. In view of this mounting problem, the Sanitary Engineering Division and the State Laboratory of Hygiene of the State Board of Health began in June 1958, with the cooperation of municipalities, a program of measurement of radiation background within the surface waters used as sources of public water supplies. Some 147 sampling points were established to sample raw surface water.

Background Radioactivity in Water

All waters contain traces of radioactivity which originate from naturally radioactive minerals dissolved from rock strata or from radioactive particulate material or gases in the atmosphere. Common among these minerals are trace elements of potassium-40, radium, thorium, and uranium. Such trace elements are dissolved by water as it finds its way to the watercourses, or as it flows within the watercourses. Precipitation is the major mechanism by which particulate matter or radioactive gases such as thoron and radon, are removed from the atmosphere.

The combination of these radioactive materials imparts radioactive characteristics to the water and constitutes what is known as "background radioactivity" of the water.

A knowledge of the concentration of this background radioactivity is an important factor in the present and future appraisal of water quality for several reasons. First, once the background radioactivity has been changed due to the addition of isotopes, fission products, or other types of radioactive material, it may not be possible to establish what the original background may have been. Second, standards pertaining to radiation exposure or concentration within drinking water are expressed in terms of "additions to the natural background" (*2*). Third, the knowledge of background radioactivity is the future yardstick by which the extent of pollution of added radioactivity and the control of such material on the watershed areas can be determined. The present program was established to determine this baseline information.

Table 3 gives the average background radioactivity as well as the maximum and minimum values recorded over the period June 1958 through October 1961. The first column consists of code numbers which indicate the geographical positions of the sampling stations shown in figure 1.

Laboratory Procedure

Total solids content is determined for each

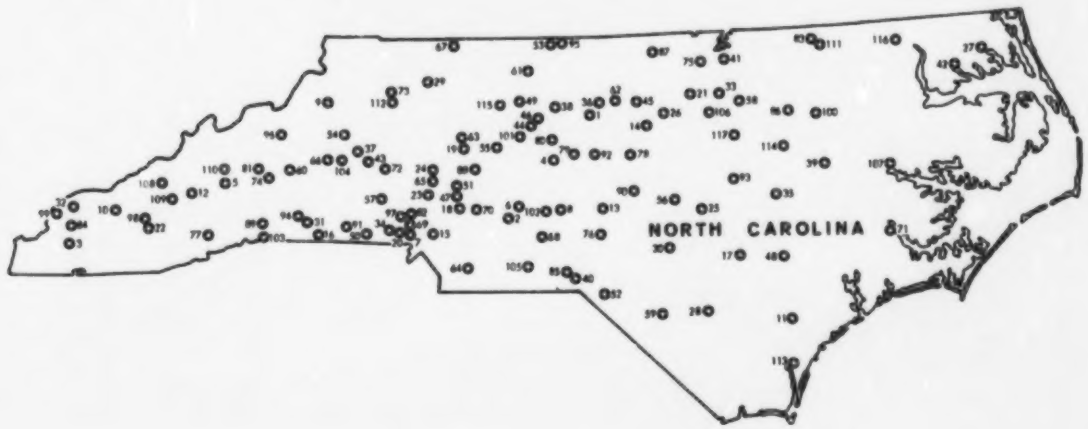

Figure 2.—NORTH CAROLINA SURFACE WATER SAMPLING STATIONS WITH CODE NUMBERS, 1958-1961

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[1] Abstracted from reference (*1*)
[2] Raleigh, North Carolina

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TABLE 3.—AVERAGE BACKGROUND RADIOACTIVITY FOUND IN RAW SURFACE WATER USED AS SOURCES OF PUBLIC WATER SUPPLIES, NORTH CAROLINA, JUNE 1958–OCTOBER 1961

Code number	Location	Source of water supply	Number of samples surveyed	Background activity in μμc/liter[b]		
				Average	Maximum[a]	Minimum
1	Alamance	Big Alamance Creek	16	7.04	9.77	3.87
2	Albemarle	Yadkin River	29	5.11	17.39	1.95
3	Andrews	Beaver Creek	16	2.58	6.11	1.14
4	Asheboro	Back Creek	15	7.94	32.62	2.31
5	Asheville	Bee Tree Creek	35	2.17	8.19	0.84
6	Badin	Yadkin River	16	6.50	14.11	2.39
7	Belmont	Catawba River	15	6.14	23.77	1.52
8	Biscoe	Little River	14	6.34	7.72	3.2
9	Blowing Rock	Brickhouse Creek	33	4.92	14.69	1.00
10	Bryson City	Lands Creek	17	1.89	5.90	1.00
11	Burgaw	NE Cape Fear River	18	9.18	29.51	2.18
12	Canton	Pigeon River; Ruff Creek	15	1.63	3.51	1.09
13	Carthage	Spring	16	4.18	9.87	1.68
14	Chapel Hill	Price Creek	16	5.39	15.9	1.69
15	Charlotte	Catawba River	33	4.61	18.08	1.36
16	Cliffside	Second Broad River	33	8.70	36.12	1.84
17	Clinton	Black River	29	5.77	31.12	1.69
18	Concord	Cold Water Creek & Lumby Creek	34	10.63	38.05	3.00
19	Cooleemee	South Fork Yadkin	16	7.66	16.70	1.20
20	Cramerton	South Fork Catawba River	16	8.46	21.20	1.77
21	Creedmoor	Ledge Creek	16	10.60	17.8	2.56
22	Cullowhee	Long Branch; Flat Creek	15	2.37	4.86	1.25
23	Davidson	Cathy's Creek	14	4.80	6.9	2.92
24	Denton	Lick Branch	15	13.04	31.66	2.64
25	Dunn	Cape Fear River	11	15.97	49.90	5.21
26	Durham	Flat River	32	9.71	25.97	2.83
27	Elizabeth City	Pasquotank River	16	15.96	23.6	10.30
28	Elizabethtown	Cape Fear River	21	6.84	24.52	2.16
29	Elkin	Big Elkin Creek	17	3.98	12.15	1.11
30	Fayetteville	Cape Fear River	30	6.94	39.84	1 37
31	Forest City	Second Broad River	16	7.26	34.20	2.02
32	Fontana Dam	Little Tennessee River	16	2.94	9.3	1.04
33	Franklinton	Kearney's Creek	17	5.90	14.21	1.98
34	Gastonia	Long Creek; Catawba River	33	5.74	28.38	1.75
35	Goldsboro	Little River; Neuse River	20	10.25	27.02	1.83
36	Graham	Back Creek	16	8.56	12.70	4.32
37	Granite Falls	Catawba River	15	3.95	11.22	1.13
38	Greensboro	Reedy Fork Creek	34	8.59	30.60	2.07
39	Greenville	Tar River	31	8.58	29.66	2.27
40	Hamlet	Marks Creek	15	7.54	28.76	1.34
41	Henderson	Sandy Creek	10	5.91	18.69	2.49
42	Hertford	Perquimans River	16	15.30	26.10	5.21
43	Hickory	Catawba River	30	4.41	12.25	1.04
44	High Point	Deep River	27	11.52	35.26	2.69
45	Hillsboro	Eno River	17	6.84	21.4	2.65
46	Jamestown	Deep River	13	15.39	26.86	1.31
47	Kannapolis	Buffalo Creek	33	7.07	29.72	1.35
48	Kenansville	NE Cape Fear River	11	11.94	47.00	1.72
49	Kernersville	Belew's Creek	14	6.81	19.15	2.38
50	Kings Mountain	Kings Creek	16	2.35	19.63	1.77
51	Landis	Grant's Creek	16	7.25	33.35	2.02
52	Laurinburg	Jordan Creek	17	4.30	17.20	0.99
53	Leaksville	Dan River	32	9.64	63.10	2.46
54	Lenoir	Zacks Fork Creek & Catawba River	15	5.62	12.36	1.48
55	Lexington	Abbott's Creek	16	8.96	20.56	2.69
56	Lillington	Cape Fear River	16	10.79	30.4	4.78
57	Lincolnton	Walker Branch	16	4.89	4.25	1.53
58	Louisburg	Tar River	14	6.28	23.39	2.48
59	Lumberton	Lumber River	32	6.16	17.12	1.52
60	Marion	Mackey's Creek; Buck Creek	18	1.34	2.03	0.87
61	Mayodan	Mayo River	17	7.81	37.70	1.60
62	Mebane	Mills Creek	15	4.48	7.20	1.69
63	Mocksville	Bear Creek	17	15.06	81.90	2.61
64	Monroe	Richardson Creek	17	13.19	52.05	2.58
65	Mooresville	Byers Creek; Catawba River	19	8.44	43.33	2.30
66	Morganton	Henry River	17	1.82	3.70	1.05
67	Mount Airy	Lovell's Creek	17	2.38	5.90	1.01
68	Mount Gilead	Pee Dee River	16	7.48	41.13	2.05
69	Mount Holly	Catawba River	16	4.15	13.93	1.43
70	Mount Pleasant	Duten Buffalo Creek	14	9.19	20.57	3.27
71	New Bern	Neuse River	22	5.07	10.34	1.59
72	Newton	Jacobs Fork	11	9.01	28.49	1.39
73	North Wilkesboro	Reddies River	31	6.03	52.72	1.18
74	Old Fort	Jarrett Creek	16	2.04	5.23	1.13
75	Oxford	Tar River; Hatcher's Run	16	9.30	43.88	2.22
76	Pinehurst	Rattlesnake Branch; Juniper Branch	15	3.59	12.86	1.34
77	Pisgah Forest	Davidson River	15	3.59	12.85	0.89
78	Pittsboro	Robinson Creek	17	8.98	35.89	3.35
79	Ramseur	Sandy Creek	17	6.28	14.51	2.21
80	Randleman	Pole Cat Creek	16	15.95	69.31	3.30
81	Ridgecrest	Mountain Stream	17	1.55	2.99	0.89
82	Riverbend	Catawba River	17	4.72	18.34	1.86
83	Roanoke Rapids	Roanoke River	32	6.14	16.54	1.64
84	Robbinsville	Rock & Burgin's Creek	17	2.06	6.37	0.94

TABLE 3.—AVERAGE BACKGROUND RADIOACTIVITY FOUND IN RAW SURFACE WATER USED AS SOURCES OF PUBLIC WATER SUPPLIES, NORTH CAROLINA, JUNE 1958–OCTOBER 1961—Continued

Code number	Location	Source of water supply	Number of samples surveyed	Background activity in μμc/liter		
				Average	Maximum[a]	Minimum[b]
85	Rockingham	Falling Creek	11	6.27	18.42	1.37
86	Rocky Mount	Tar River	15	13.17	57.10	3.31
87	Roxboro	Lake Issac Walton; Storey's Creek	17	10.55	35.74	2.98
88	Salisbury	Yadkin River	14	12.31	60.20	2.57
89	Saluda	Paces Creek	17	1.80	3.50	1.06
90	Sanford	Lick Creek; Potterage Creek	17	8.67	47.35	1.72
91	Shelby	First Broad River	30	3.27	32.92	1.12
92	Siler City	Rocky River	16	9.56	34.36	2.51
93	Smithfield	Neuse River	29	13.17	28.46	4.00
94	Spindale-Rutherfordton	Hollands Creek; Cathy's Creek	17	3.35	11.55	1.90
95	Spray	Smith River	34	7.66	61.80	2.00
96	Spruce Pine	Beaver Creek	16	2.00	4.23	1.21
97	Stanley	Hoyle's Creek	17	6.36	31.13	2.07
98	Sylva	Dill's Creek	31	3.31	17.01	0.84
99	Tapoco	Yellow Hammer Creek	17	1.78	3.77	0.94
100	Tarboro	Tar River	17	8.34	32.46	1.30
101	Thomasville	Abbott's Creek	17	10.79	59.02	3.80
102	Troy	Denson Creek; Downing Creek	17	5.83	15.82	1.57
103	Tryon	Falls Creek; Vaughn's Creek	17	3.30	4.08	1.32
104	Valdese	Micol Creek; Hoyle Creek; Catawba River	17	5.86	18.40	1.83
105	Wadesboro	Jones Creek	17	7.66	33.29	1.85
106	Wake Forest	Smith's Creek	17	4.28	8.25	1.39
107	Washington	Tranters Creek	17	8.65	36.42	2.31
108	Waterville	Big Creek	17	1.55	3.03	0.94
109	Waynesville	Cherry Cove & Shiney Creek	17	2.59	9.14	1.16
110	Weaverville	Wagner Branch & Ox Creek	17	1.76	3.47	0.82
111	Wedlon	Roanoke River	17	5.30	16.11	2.69
112	Wilkesboro	Cub Creek	16	3.16	7.38	1.11
113	Wilmington	Cape Fear River	32	11.20	86.00	2.16
114	Wilson	Contentney Creek	33	3.90	28.87	2.07
115	Winston-Salem	Salem Creek	33	6.64	20.12	1.64
115	Winston-Salem	Yadkin River	33	7.31	26.04	1.24
116	Winton	Chowan River	29	7.77	25.46	1.79
117	Zebulon	Little River	16	4.62	10.60	1.64

[a] Maximum values have 95 percent accuracy ± 20 percent.
[b] Minimum values have 95 percent accuracy ± 60 percent.

sample so that proper sample proportions may be used in analysis. The calculated amount of a sample, based on solids content, is concentrated to a few milliliters on a steam bath. The residue is transfered to a stainless steel planchet and evaporated to dryness under an infrared light. After further drying for one hour at 103°C., the sample is cooled in a dessicator and is then counted.

Alpha plus beta counting is done in a gas-flow internal proportional counter which is calibrated with a radium-D E source. On the vasis of instrument background, each sample is counted for a preset count and the results are reported in terms of micromicrocuries per liter.

Interpretation of Results

The measurement of radioactivity at low levels or low concentrations is difficult because of the many variable factors such as types and energy of radiation, necessary concentration to obtain a representative sample, and efficiency of counting which includes absorption, scatter, and geometry.

All results may be interpreted on the basis of the maximum permissible continuous occupational concentration or radioactivity concentration guide set forth by the Subcommittee on Permissible Internal Dose of the National Committee on Radiation Protection. This has been established at 100 micromicrocuries per liter of water for the total activity of unknown isotopes (*3*). This value relates to average intake from water over a long period of time and not from transient conditions.

Individual sample data and associated errors are contained in reference (*1*). Only significant values were used in calculating the arithmetic averages given in this report. The significant increase in activity recorded for the period from November 9, 1961 to December 31, 1961 is probably due to the presence of fission material produced during the renewed atmospheric testing of nuclear weapons. For this reason, the values recorded during this period were not included in the calculations of the average background radioactivity.

From a study of the results, it can be noted that the mountain waters contain less radioactivity than those in the Piedmont and further east (see figure 1 and table 3). This is to be expected since the waters in the mountains contain less mineral content. As both surface and subsurface waters flow toward the ocean their dissolved solids content, paralleled by their concentrations of natural radioactivity, increases. Hence, from results to date, it cannot be assumed that the minerals in the Piedmont in the eastern part of the State necessarily contain more radioactivity than those in the western part.

Previous coverage in *Radiological Health Data:*

Period	Issue
June-August 1962 (cistern water)	*February 1962*

REFERENCES

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(*2*) International Commission on Radiological Protection: *Recommendations of the International Commission on Radiological Protection (Adopted September 9, 1958)*, Pergamon Press, New York (1959).

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SECTION IV.—OTHER DATA

Control of Luminous Dial Watches in New York City

Ira R. Paul[1]

Introduction

The Office of Radiation Control of the New York City Department of Health was created for the purpose of administering a control program to protect the general public, as well as workers in certain installations, from the dangers inherent in the uncontrolled use of radioactive materials or ionizing radiation. Most of its efforts concern the use of X rays and radioactive materials including radium, in medical installations, schools and institutions, but occasionally it is necessary to deal with other radiation problems. One of these, the use of radioactive materials in watches, is of particular interest because of the widespread use and popularity with young people of luminous-dial watches.

New York City's efforts to limit the public exposure from radium-dial timepieces began on March 19, 1958, with the enactment of Article 175 of the New York City Health Code which prohibited the "storage, manufacture, repair, handling, or use of any timepieces, instruments, novelties or devices, if done in such a manner that any person is exposed to radiation dose rates in excess of limitations recommended by the National Committee on Radiation Protection and Measurements (*1*)."

Upon the recommendation of the Mayor's Technical Advisory Committee on Radiation, these dose rates were interpreted to limit the radiation emission through the front surface of pocket watches to no more than 0.1 mrad per hour and the radiation emission through the back surface of wrist watches to no more than 1.0 mrad per hour.

It was estimated, by general observation, that pocket watches are worn for an average of 100 hours per week, 50 weeks per year, facing the body in a pocket near the belt-line. Wrist watches may be worn with the back surface in contact with the skin of the forearm for approximately 150 hours per week, and thus it was necessary to establish separate criteria for each of these two styles of watches.

The National Committee on Radiation Protection and Measurements (NCRP) (*2*) has recommended that the maximum permissible dose (MPD) to the head, trunk, active blood-forming organs, gonads or lens of the eye of radiation workers shall not exceed 5 rems per year, and the maximum permissible dose to the hand or forearms shall not exceed 75 rems per year. The NCRP has further advocated the principle that the general population should not receive radiation at a weekly rate higher than one-tenth the respective permissible weekly dose for the critical organs and other body tissues.

The Federal Radiation Council's Radiation Protection Guides (RPG) (*3*) also recommended the above values not be exceeded for radiation workers. When considering individual members of

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the population, a whole body dose of 0.5 rem per year should not be exceeded. Similarly, with an average mumber of the population, a 30-year gonadal dose of 5 rem should not be exceeded. As an operational technique, where the individual whole body doses are not known, a suitable sample of the exposed population should be developed whose protection guide for annual whole body dose will be 0.17 rem per capita per year. The FRC has not recommended specific guides for exposure of the hands and forearms.

Using the NCRP dose rates as a guide for control at the radiation source rather than at the organ of interest, it then follows that if a pocket watch is worn for 5,000 hours per year, and the MPD is 0.5 rems (500 mrems), then the emission rate at the surface of the crystal should be a maximum of 0.1 mrad per hour. If a wrist watch is used for 7,500 hours per year, and the MPD is 7.5 rems (7,500 mrems), then the emission rate at the surface of the back should be a maximum of 1.0 mrad per hour.

Numerous wrist watches were tested and, with the exception of some skin-divers watches, were found to fall within the established limits.

Literature Survey

Joyet (*4*) reported in 1958 that the average man's luminous wrist watch contains 0.36 microcuries of radium and the average woman's wrist watch contains 0.13 microcuries. He calculated that a man wearing such a watch 24 hours a day receives a gondal dose of 21.8 mr per year and a woman receives a gondal dose of 12.7 mr per year.

Using Joyet's results, a sampling by the New York AEC operations office of 224 persons (including those not wearing watches and those wearing watches with non-luminous dials) in New York City indicated an average gonadal exposure of 3 mr per year per person to age 35. The 35-year dose is then about 0.1 r, which amounts to approximately 3 percent of natural background radiation and only about 1.5 percent of the total radiation dose derived from background plus medical and dental exposure to the gonads, as currently estimated (*5*).

Eng, LeCoultre and Lerch (*6*) examined 684 wrist watches produced in Switzerland in 1961, and found the highest percentage of these watches contained approximately 0.1 microcuries of radium-226 and emitted less than 1 mrem per hour through the back. Quite evidently, the trend has been to reduce the amount of radium on watches.

Seelentag and Schmier (*7*) state that most German-made watches have radium amounting to less than 0.06 microcuries and usually only about 0.02 microcuries. The radiation exposure to wearers of such watches amounts to a small percentage (about 1 percent) of natural background radiation exposure, and the local exposure to the skin of the forearm amounts to only a few percent of the maximum permissible occupational dose.

Although no comparable study has been made with radium-dial pocket watches, the fact that they are worn in relatively close proximity to the gonads, roughly 28 cm for the average male, makes the pocket watch potentially a much greater genetic hazard than a wrist watch with equal amounts of radium-226. In considering the dose to the abdomen, the fact that the radium emanations are shielded only by the thin glass crystal and a few mg/cm^2 of cloth, rather than the mechanism and back of the wrist watch, again makes the pocket watch a potentially greater hazard to the wearer.

Survey Results and Laboratory Calibration Procedures

In 1960, a large department store and a large cutlery chain, both in New York City, advertised radium-dial pocket alarm watches. Samples of these watches were obtained and tested, and were found to emit 4 mrads per hour at their faces. The stores were notified, and they voluntarily removed these watches from sale.

In 1962, the manager of a mail order company, after being informed that the radiation emission from the pocket watches he had advertised was excessive, complained that there were many other sales outlets for these watches throughout the city. An inspection team was sent out and took a random sampling of 77 jewelry, department, novelty, and cigar stores. About half of these stores were found to be stocking radium dial pocket watches.

Rough field measurements, made with a portable end-window G-M survey meter having scale ranges of 0–30 and 0–100 mr/hr and a window thickness of 1.5 to 2.0 mg/cm^2, gave readings of from 3 to 10 mr/hr for various makes and models, with the window of the probe in contact with the surface of the watch crystal.

Admittedly, this procedure was crude, but since

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all readings were on the low side due to poor geometry, it established the fact that all of the pocket watches checked exceeded the acceptable limits. Calibration of the instrument was obtained utilizing a 10.08 mg radium needle encapsulated in 0.5 mm of platinum, and using a factor of 0.825 to convert the mg of radium to mr per hour at a meter.

Two pocket alarm watches were placed in the whole body counter at the Atomic Energy Commission's New York Operations Office. Watch "A" was estimated to contain 0.15 microgram of radium, and watch "B" 0.015 microgram of radium. When checked with the G-M counter, the dose reading at the surface of the crystal of watch "A" was 8 mrad per hour and that of watch "B" was 1.2 mrad per hour.

To check depth of penetration in tissue, a pocket watch "C" which gave a reading of 8 mrad per hour on the G-M meter, and another pocket watch "D" which gave a reading of 3 mrad per hour, were used as radiation sources with an approximately tissue-equivalent pressed-wood phantom. Watch "C" had a gamma component that penetrated 8.25 inches of the phantom before reaching background levels and the gamma component of watch "D" penetrated 2.44 inches.

Again it is emphasized that the G-M meter is used only for fast field determinations. A more precise method, used in the laboratory, utilizes films. Exposure dose rates obtained by the film method are about three times higher than those obtained for the same watch by the G-M meter method.

Because a fast film is desirable, it was found convenient to use the same personnel dosimeter packet, Dupont type 556, that is used to monitor our laboratory and field personnel. This is a double film packet with a sensitive component, type 508, and an insensitive component, type 834. Only the sensitive film, the 508, which is at the front of the packet, is utilized for watch dosimetry.

Autoradiographs are obtained by taping two packets, side by side, on the face of the pocket watch, with the front of the packet in contact with the crystal. The films are left in place for two to three days. The time necessary to produce a satisfactory autoradiograph was previously determined by G-M counter measurement. During this time, the watch is kept wound, to simulate actual wearing conditions. In this way, the radium on the moving hands will distribute its energy over the area of the face, rather than concentrate it in one spot. Numbers or spots on the dial that are coated with radium are naturally stationary, and the film will receive greater exposure at these points. This is not too distinct, however, since a great deal of scattering takes place within the glass crystal, resulting in a blurred image. Figure 1 shows an example of an autoradiograph produced using this procedure. An autoradiograph made with the hands stationary is also shown (figure 2) to demonstrate that improper technique (watch not wound) would give false readings.

The films are developed along with unexposed films from the same emulsion batch. The purpose of these unexposed films is to establish a base and fog limit. After thorough drying, the net density of the films is determined with a densitometer. The "net density" is the density above base density and fog. Thus, net density is the density produced by the exposure (*8*).

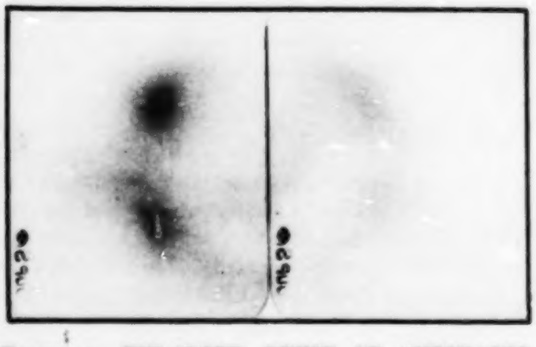

FIGURE 1.—ENLARGED PRINT OF AUTORADIOGRAPH FOR WATCH WOUND DURING EXPOSURE TIME

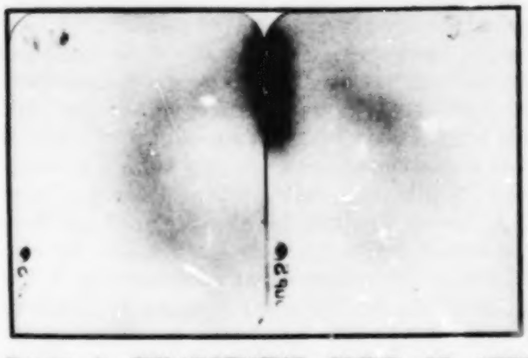

FIGURE 2.—ENLARGEMENT PRINT OF AUTORADIOGRAPH FOR WATCH UNWOUND DURING EXPOSURE TIME

The results are then compared against a radium-226 calibration curve (see figure 3). To establish this curve, the same radium source is used that is used to calibrate the G-M counter. Dupont type 556 film packets are placed a distance of one meter from the source, and removed individually at varying time intrvals. The exposure received by each film is checked with a Victoreen Condenser R-Meter thimble chamber. After development and determination of the net density of each film the net densities are plotted against exposure in milliroentgens on semilogarithmic paper, and a characteristic curve is obtained (*9*). Because the steepest slope occurs between net densities of 0.3 and 1.0, the exposure time of the watch film is estimated to bring the exposure into this curve segment.

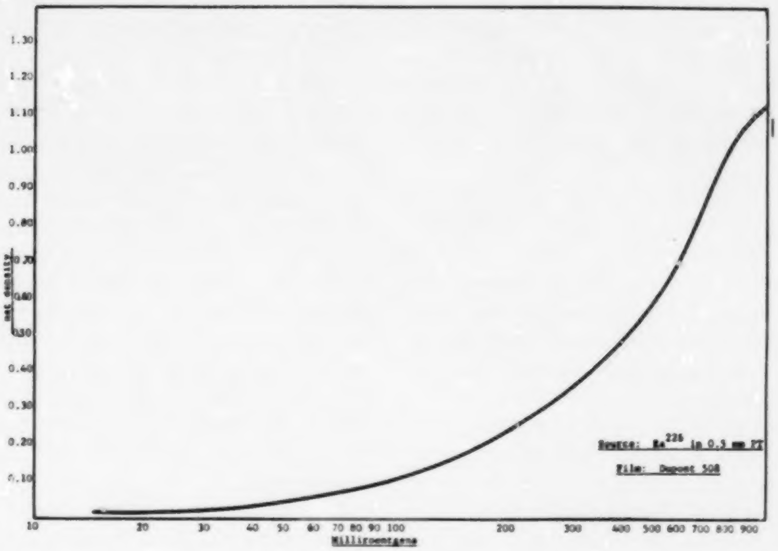

FIGURE 3.—RADIUM-226 CALIBRATION CURVE

This is, of course, a gamma curve to which a beta-gamma exposure is being related. The beta component of the watch-dial radium which penetrates the glass crystal, the white and green protective film papers (weight = 27.4 mg/cm^2) and the film emulsion itself is in the energy range above 0.5 Mev (10). The response of photographic film has been studied by Fleeman and Frantz (*11*) for beta radiation energies ranging from 0.5 to 1.4 Mev. Within these limits, film response was found to be proportional to the dose received and independent of the energy of the incident electrons.

Most of the beta particles are filtered out before reaching the emulsion, but radium E (bismuth-210) has a 1.17 Mev beta which has a range of 500 mg/cm^2 (*10*). The beta-ray sensitivity of the film is almost proportional to the gamma-ray sensitivity, and therefore the film densities are based upon a 1-to-1 beta-gamma ratio (*12, 13*).

Using this method, gamma skin dose rates as high as 20 mrads per hour, or 200 times the authorized emission rates, were recorded. These values indicated some action had to be taken.

Regulatory Action.

A notice to manufacturers and distributors of radium dial pocket watches was issued by the Office of Radiation Control, which set forth the interpretations of the Mayor's Technical Advisory Committee on Radiation as previously stated. The notice requested that the offer for sale or supply of radium-dial pocket watches to retail stores within New York City be discontinued at once, and that all existing stocks on consignment from retail outlets be withdrawn by February 1, 1963.

Following this, New York City Board of Health enacted the following amendment to the "Radiological Hazards" section of the Health Code, to become effective on February 1, 1963:

"A permit shall be required for any timepiece, instrument, novelty or device containing radioactive material other than hydrogen-3 (tritium), if the regular use thereof in the usual manner will expose the user to a radiation dose in excess of 0.5 rems per year to the head, trunk, active blood-forming organs, gonads, or lens of the eye, or will expose the hands or forearms to a dose in excess of 7.5 rems per year, when used regularly."

The new amendment does not necessarily mean that watches having excessive quantities of radium are absolutely prohibited from sale. Such a watch may be sold to anyone having a Health Department permit to possess one. This is to allow anyone who might have a legitimate professional need for such a watch to use one under the necessary safeguards prescribed in the terms of a license.

Summary

The New York City Department of Health has enacted an amendment to the Health Code, affecting timepieces containing radioactive material other than tritium, which considers the recommendations of the NCRP and the FRC. This has been interpreted by the Mayor's Technical Advisory Committee on Radiation to limit the radiation emission from the front of pocket watches to 0.1 mrad per hour, and from the back of wrist watches to 1.0 mrad per hour.

Rough field measurements of watches are made with an end-window G-M survey meter, but more precise measurements make use of autoradiographs on personnel dosimeter film.

Any person desiring the purchase a watch that emits radiation in excess of the specified limits may do so by demonstrating a legitimate, professional need and securing a permit from the New York City Department of Health.

Acknowledgment

I wish to express my appreciation to Hanson Blatz, Director of the Office of Radiation Control, for making available his files and correspondence, which aided immeasurably in the preparation of this paper.

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Enviromental Levels of Radioactivity of Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors quarterly reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 22 AEC installations have appeared periodically in *Radiological Health Data* since November 1960. Summaries follow for Argonne National Laboratory, Portsmouth Area Gaseous Diffusion Plant, and Shippingport Atomic Power Station.

The measured concentration of a radionuclide in air and water may be compared with the Maximum Permissible Concentration (MPC) of that nuclide as recommended by the National Committee on Radiation Protection and Measurement (NCRP). For the environment near an AEC installation, the applicable MPC's are one-tenth of the occupational MPC values for continuous exposure given in the National Bureau of Standards "Handbook 69" (NCRP report no. 22). The MPC values applicable to the reports that follow are given in table 1.

In these reports, nonspecific terms such as "total activity," "total alpha," and "gross beta" do not in themselves suggest any one MPC value. Often, when concentrations are low a laboratory will assign an MPC value that is more restrictive than necessary. This avoids the more costly isotopic tests necessary to justify a less restrictive value. References to table 1 will be made to designate the appropriate MPC's adopted by the respective laboratories.

TABLE 1.—SELECTED ENVIRONMENTAL MPC VALUES PERTAINING TO AEC INSTALLATION REPORTS IN THIS SUBSECTION

Line No.	Radionuclide or mixture of radionuclides	Environmental MPC's	
		Water ($\mu\mu c$/liter)	Air ($\mu\mu c/m^3$)
1	If Sr^{90}, I^{129}, Pb^{210}, Po^{210}, Ra^{223}, Ra^{226}, Ra^{228}, Pa^{231}, and Th-nat are not present[a]	2,000	—
2	If Sr^{90}, Pb^{210}, Ra^{226}, Ra^{228} are not present[a]	600	—
3	If Ra^{226}, Ra^{228} are not present[a]	100	—
4	Mixture of unidentified nuclides	10	0.04
5	If α emitters and Ac^{227} are not present[a]	—	1.0
6	If α emitters and Pb^{210}, Ac^{227}, Ra^{228}, and Pu^{241} are not present[a]	—	10
7	If α emitters and Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{230}, Pu^{241}, and Bk^{249} are not present[a]	—	100
8	Barium-lanthanum-140	20,000	4,000
9	Cerium-141	90,000	5,000
10	Cerium-144	10,000	300
11	Cesium-137	20,000	500
12	Cobalt-58	90,000	2,000
13	Cobalt-60	50,000	300
14	Hydrogen-3 (tritium)	3,000,000	500,000
15	Iodine-131	2,000	300
16	Plutonium-239	5,000	0.06
17	Ruthenium-103	80,000	20,000
18	Ruthenium-rhodium-106	10,000	200
19	Strontium-89	10,000	1,000
20	Strontium-90	100	10
21	Thorium-232	2,000	1
22	Thorium-protactinium-234	20,000	2,000
23	Uranium, natural	20,000	2
24	Xenon-133	—	300
25	Zirconium-niobium-95	60,000	1,000

[a] "Not present" implies the concentration of the nuclide is small compared with its appropriate MPC. According to AEC regulation (Federal Register, Title 10, Part 20, August 9, 1961), a group of nuclides may be considered not present if the ratio of each nuclide to its appropriate MPC is equal to or less than 1/10 and if the sum of these ratios for the group in question is equal to or less than ¼.

ARGONNE NATIONAL LABORATORY
1962

University of Chicago,
Lemont, Illinois

Air Monitoring

Weekly continuous air filter samples were collected at seven locations on the Argonne National Laboratory (ANL) site as shown in figure 1 and at 5 off-site locations at Aurora (west of ANL site), Wheaton (northwest), Hinsdale (northeast), Joliet (southwest), and Tinley Park (southwest). The quarterly averages of alpha, beta, and several nuclide concentrations are given in table 2. The radionuclide determinations were made by gamma spectra of manthly composites of the filters. The data show little difference between off-site and on-site measurements for alpha activity and most of the nuclides, inferring that ANL does not contribute detectable quantities of these activities to the atmosphere.

Water Monitoring

ANL waste water is discharged into Sawmill Creek, a stream that runs through the Argonne grounds and enters the Des Plaines River about 500 yards downstream from the waste water discharge. Sampling locations on Sawmill Creek and Des Plaines River are shown in figures 1 and 2 respectively.

On Sawmill Creek, weekly grab samples are collected upstream and three times a week samples are collected downstream from the waste water outfall. The upstream flow is roughly equal to the waste water flow, yielding a dilution factor of one-half. The data in table 3 show significantly higher concentrations downstream than upstream, an indication of the radioactivity contributed to the stream by ANL. A comparison of the downstream concentrations with the environmental MPC's listed in table 1 shows that all concentrations are relatively low.

Weekly grab samples are collected from the Des Plaines River upstream and downstream from its junction with Sawmill Creek. The results indicate that the dilution factor of the Des Plaines River is so large that the radioactivity contribution from ANL was not detected.

Previous coverage in *Radiological Health Data:*

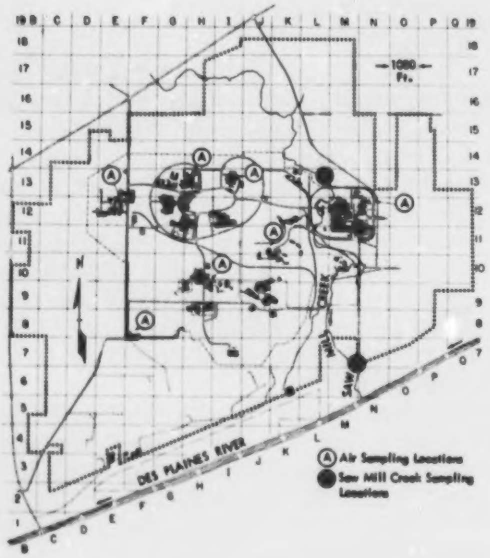
Period	Issue
1959 and first quarter 1960	*December 1960*
Second quarter 1960	*April 1961*
Third and fourth quarters 1960	*July 1961*
First and second quarters 1961	*December 1961*
Third and fourth quarters 1961	*May 1962*

TABLE 2.—RADIOACTIVITY OF AIRBORNE PARTICULATES, ANL 1962

[Concentrations in $\mu\mu c/m^3$]

Type of analysis	Sampling locations	1962 quarterly averages				1962 average
		1st quarter	2nd quarter	3rd quarter	4th quarter	
Alpha	on-site	0.0036	0.0054	0.0049	0.0055	0.0048
	off-site	0.0039	0.0052	0.0051	0.0060	0.0050
Beta	on-site	5.1	5.5	3.4	5.5	4.9
	off-site	4.9	5.1	3.3	5.7	4.8
Ba-La^{140}	on-site	[a]<0.01	0.032	0.60	1.5	0.56
	off-site	[a]<0.01	0.025	0.66	1.8	0.61
Ce^{141}	on-site	0.27	0.36	0.31	0.46	0.36
	off-site	0.23	0.39	0.29	0.45	0.34
Ce^{144}	on-site	0.85	1.6	1.0	1.5	1.3
	off-site	1.0	1.5	1.0	2.2	1.4
Cs^{137}	on-site	0.028	0.090	0.040	0.028	0.046
	off-site	0.034	0.065	0.042	0.030	0.043
Ru^{103}	on-site	0.38	0.23	0.21	0.44	0.32
	off-site	0.43	0.24	0.26	0.47	0.36
Ru-Rh^{106}	on-site	0.29	0.50	0.39	0.30	0.38
	off-site	0.30	0.51	0.37	0.30	0.38
Zr-Nb^{95}	on-site	1.9	1.6	0.86	1.3	1.4
	off-site	2.1	1.7	0.85	1.4	1.5

[a] Not analyzed during January and February.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N
DES PLAINES RIVER
SAW MILL CREEK
Ⓐ Air Sampling Locations
● Saw Mill Creek Sampling Locations

FIGURE 1.—ON-SITE SAMPLING LOCATIONS, ARGONNE NATIONAL LABORATORY

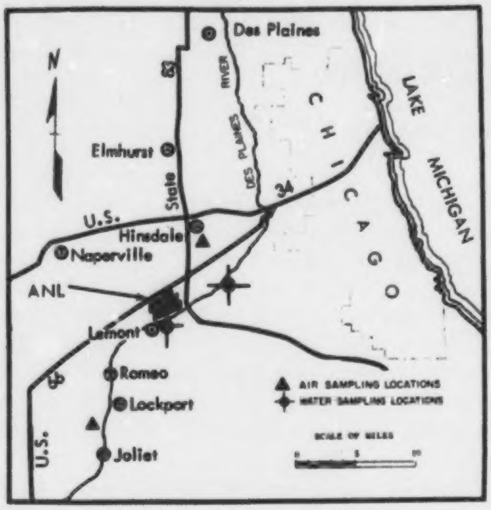
Des Plaines
N
Elmhurst
State 53
DES PLAINES RIVER
CHICAGO
LAKE MICHIGAN
U.S. 34
Hinsdale
Naperville
ANL
Lemont
Romeo
Lockport
Joliet
U.S.
▲ AIR SAMPLING LOCATIONS
WATER SAMPLING LOCATIONS
SCALE OF MILES
0
5
10

FIGURE 2.—SITE LOCATION OF ARGONNE NATIONAL LABORATORY (INCLUDING SOME OFF-SITE SAMPLING STATIONS)

TABLE 3.—RADIOACTIVITY IN SAWMILL CREEK, ANL, 1962

Type of analysis	Sampling locations	Concentrations ($\mu\mu c$/liter)		
		Maximum	Minimum	1962 Average
Alpha emitters:				
Total alpha	upstream	4.1	0.2	1.6
	downstream	16.4	0.8	5.0
U-natural	upstream	1.9	0.4	1.0
	downstream	7.6	0.9	2.8
Pu^{239}	upstream	<0.05	<0.05	<0.05
	downstream	0.91	<0.05	0.12
Th^{232}	upstream	0.10	<0.05	<0.05
	downstream	0.48	<0.05	0.12
Beta emitters:				
Total beta	upstream	393	10	40
	downstream	806	17	66
Co^{58}	upstream	<5	<5	<5
	downstream	3,260	<5	136
Co^{60}	upstream	<3	<3	<3
	downstream	75	<3	6
Sr^{89}	upstream	56	<2	12
	downstream	25	<2	9.5
Sr^{90}	upstream	2.4	<0.5	1.2
	downstream	3.1	<0.5	1.2
I^{131}	upstream	<3	<3	<3
	downstream	11	<3	<3
Cs^{137}	upstream	7.7	<0.5	1.8
	downstream	254	<0.5	7.6
Ba^{140}	upstream	3.4	<1	<1
	downstream	1.8	<1	<1
$Th\text{-}Pa^{234}$	upstream	1.5	0.3	0.8
	downstream	6.1	0.7	2.2

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PORTSMOUTH AREA GASEOUS DIFFUSION PLANT
1962

Goodyear Atomic Corporation
Portsmouth, Ohio

The separation of uranium isotopes by the gaseous diffusion process presents control problems similar to any chemical process using toxic solvents and extraction solutions. Natural uranium and thorium-234 are the most likely radionuclides to be released to the environment by the Portsmouth Area Gaseous Diffusion Plant. Since natural uranium is an alpha emitter and thorium-234 is a beta-gamma emitter, environmental monitoring is conducted for evidence of alpha and beta-gamma emitters to test the effectiveness of plant controls.

Air samples are collected monthly at 17 sites located from 1 to 6 miles from the plant as shown in figure 3. Monthly water samples are collected at 14 locations within 5 miles of the plant.

Average alpha and beta-gamma concentrations in air and water are summarized in table 4. The external gamma levels are measured at the air sampling locations shown in figure 3 and the results included in table 4.

Water alpha and beta-gamma concentrations remain essentially unchanged from previous quarters. The slight increase in external gamma dose rate is evidently a consequence of nuclear weapons testing fallout. Total amount of radiation detected was too small to determine the amount, if any, attributable to plant operations.

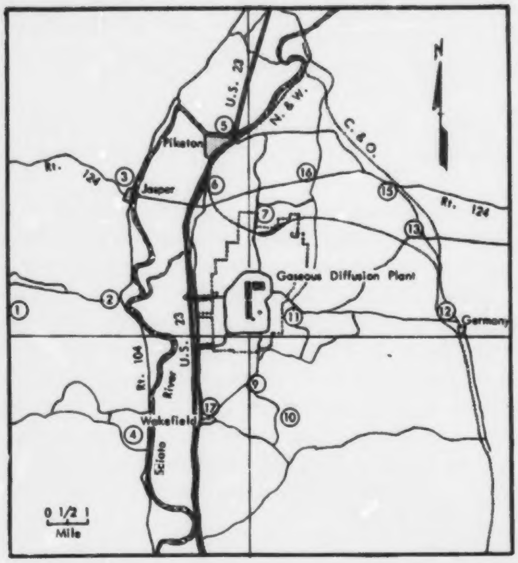

FIGURE 3.—AIR SAMPLING LOCATIONS, PORTSMOUTH GASEOUS DIFFUSION PLANT

Previous coverage in *Radiological Health Data:*

Period	Issue
1959 and first quarter 1960	*November 1960*
Second and third quarters 1960	*March 1961*
Fourth quarter 1960	*August 1961*
First and second quarters 1961	*February 1962*
Third and fourth quarters 1961	*September 1962*

TABLE 4.—ENVIRONMENTAL RADIOACTIVITY, PORTSMOUTH PLANT, 1962

Basis of measurement	Number of samples	Unit	Maximum	Minimum	1962 average
Air (alpha concentration)	180	μμc/m^3	0.7	0.1	0.1
Air (beta-gamma concentration)	180	μμc/m^3	39.3	0.1	5.7
Water (alpha concentration)	162	μμc/liter	1,105	0.5	25.6
Water (beta-gamma concentration)	162	μμc/liter	1,030	14	61
External gamma	180	mrad/hr	0.076	0.015	0.038

SHIPPINGPORT ATOMIC POWER STATION

Second Half 1961 and First Half 1962

Duquesne Light Company,
Shippingport, Pennsylvania

Environmental radiation monitoring at the Shippingport Atomic Power Station began with a two-year preoperational survey program to establish background levels at the site of the world's first large-scale nuclear-powered electric generating station. Following initial operation of the plant in December 1957, this program was continued as orginally conceived through the third quarter of 1961, when it was determined that fewer sampling locations closer to the plant would provide equal or better evaluation of the effects of plant operation on the environment.

Area Monitoring

Reduced air monitoring is apparent from an examination of figure 4. Only two on-site monitoring trailers currently operate at the eastern and western boundaries, and one off-site unit operates at Midland. Air samples are collected continuously at each trailer and monitored for gross beta activity. Average concentrations of radioactivity in air for the last half of 1961 and the first half of 1962 are presented in table 5.

Beta-gamma radiation levels are also continuously monitored at these stations. There was no significant difference in average levels measured during the year under consideration from those of previous years. The average beta-gamma level for the last half of 1961 was 0.015 mrem/hr, and during the first half of 1962 the average beta-gamma level was 0.022 mrem/hr.

Until December 1961, fallout samples were collected weekly on gummed paper trays. No fallout samples were collected during December, but collections have been made monthly at the three monitoring stations since collection pots were placed in service on December 29, 1961. Fallout gross beta activity data for the year ending June 30, 1962 are summarized in table 6. Increased fallout levels during this time are attributed to fallout from weapons tests since there was no indication of any plant contribution.

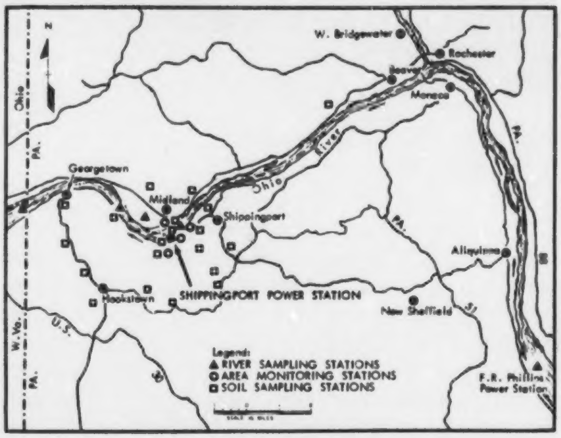

FIGURE 4.—SHIPPINGPORT POWER STATION SAMPLING LOCATIONS

TABLE 5.—AIRBORNE PARTICULATE RADIOACTIVITY, SHIPPINGPORT

[Average concentrations in μμc/m³]

Values	Third quarter 1961	Fourth quarter 1961	Calendar year 1961	First half 1962
Minimum	0.08	0.08	0.06	0.08
Maximum	8.0	7.1	7.5	6.7
Average	1.5	1.5	1.2	0.89

Release of Radioactive Wastes to the Atmosphere

An incinerator for burning contaminated combustible material is located in the waste disposal plant. The exhaust from the incinerator passes through a wet gas scrubber and a filter before entering the stack.

During the third quarter of 1961, a total of 4,636 microcuries of gaseous radioactive waste (primarily xenon-133) was released to the atmosphere at a controlled rate over a period of 93 hours and 27 minutes. During the fourth quarter a total of 13,993 microcuries of gaseous radioactive waste (primarily xenon-133) was released to the atmosphere at a controlled rate over a period of 183 hours, the average concentration at the stack exit during release being 5,000 μμc/m³. For 1961 as a whole, the release of these wastes totaled 103.5 millicuries, and the concentration at the stack exit during release average 8,100 μμc/m³. There was no release of gaseous radioactivity to the atmosphere from the waste disposal system during the first half of 1962.

Liquid Radioactive Waste Monitoring

Tritium (H^3) is released periodically in controlled quantities and concentrations to the Ohio River. Toward the end of 1960, the ion exchange resin in

TABLE 6.—GROSS BETA ACTIVITY IN FALLOUT, SHIPPINGPORT

[Average concentrations in mc/km²/month][a]

Sampling locations	Third quarter 1961	Fourth quarter 1961	Calendar year 1961	First half 1962
Upwind:				
½ mile SW of site	3.8	[b]RFS	1.9	[c]
½ mile NW of site	12.1	187	50.5	[c]
Downwind:				
On site SE of main bldg	9.0	6.3	525	[c]
½ mile NE of site	199	149	39.4	[c]
Average of all stations (except SW upwind)			47.4	[c]
Pot No. 1[d]	—	—	—	52.5
Pot No. 2	—	—	—	39.4
Pot No. 3	—	—	—	50.5

[a] One mc/km² = 2.59 mc/mi². [b] Removed from service. [c] Discontinued in 1962. [d] Collection of fallout in pots began December 29, 1961.

the reactor coolant purification system was changed from a natural lithium hydroxyl form to a lithium-7 enriched form. This change resulted in a decrease in tritium production within the reactor by a factor of about 30. The average total daily tritium activities released to the Ohio River during the last two quarters of 1961 were 7,000 and 4,000 respectively. The average tritium concentrations in the plant effluent channel during these periods were 53 μμc/liter and 37 μμc/liter, respectively. During the first half of 1962, the average total daily tritium activity released to the Ohio River was 3,900 μc and the average concentration in the plant effluent was 39 μμμc/liter.

Gross radioactivity of unidentified nuclides (does not include tritium) discharged during the last half of 1961 averaged 493 μc/day in the third quarter and 415 μc/day in the fourth quarter. Average concentrations in the effluent channel during release in these periods were 4.0 and 3.2 μμc/liter, respectively. During the first half of 1962, gross radioactivity of unidentified nuclides averaged 222 μc/day and totaled 40,323 microcuries. Monthly average concentrations in the effluent channel during releases in this period ranged from 1.5 to 4.2 μc/liter. These concentrations are in addition to normal background radioactivity in the condenser cooling water used for dilution in the effluent channel prior to discharge to the Ohio River.

The revised liquid radioactive waste sampling program became effective in the fourth quarter of 1961 and the first quarter of 1962 as follows: River water sampling was reduced by the end of the first quarter 1962 to weekly samples taken continuously at the plant intake and outfall to the Ohio River. These samples are analyzed for gross alpha and gross beta activity in suspended and dissolved solids and for total potassium-40 activity. After the third quarter of 1961, sampling at Phillips power Station and Dam No. 7 was discontinued, and by the end of the first quarter of 1962 sampling was also discontinued at the midland and East Liverpool stations (see figure 4); however the Pennsylvania State Health Department assumed responsibility for sampling and analytical programs at the latter two stations. Results for the last half of 1961 and the first half of 1962 are summarized in table 7.

Other Sampling Activities

Several programs of environmental sampling are of some interest to the Pennsylvania Department of Health. Two of these are currently active; a third, that of sampling vegetation and aquatic life, has been eliminated. River sediment and silt sample collections are made semiannually and sent as directed to the State Health Department for analysis. A series of ten soil samples are collected each year to be retained for later analysis if such data is required.

Previous coverage in *Radiological Health Data*:

Period	Issue
1959	*July 1960*
First quarter 1960	*December 1960*
Second quarter 1960	*January 1961*
Third and fourth quarters 1960	*October 1961*
First and second quarters 1960	*April 1962*

TABLE 7.—GROSS ALPHA AND BETA CONCENTRATIONS IN THE OHIO RIVER

[Average concentrations in μμc/liter]

Sampling station	Third quarter 1961		Fourth quarter 1961		Calendar year 1961		First half 1962	
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
Upstream:								
Phillips Power Station	1.0	12.4	[a]	[a]	[a]	[a]	[a]	[a]
Shippingport intake	1.3	17.7	4.9	31.8			3.9	38.8
Downstream:								
Shippingport outfall	1.2	27.7	1.2	25.9			2.0	42.1
Midland intake	1.8	15.8	3.2	34.8	[b]	[b]	[b]	[b]
Dam No. 7	1.4	12.5	[a]	[a]	[a]	[a]	[a]	[a]
East Liverpool, Ohio	1.1	11.5	1.4	24.3	[b]	[b]	[b]	[b]

[a] Station discontinued sampling after third quarter 1961.
[b] Monitored separately by the Pennsylvania Department of Health since the end of 1961.

Reported Nuclear Detonations

APRIL 1963

Only one nuclear detonation was announced by the Atomic Energy Commission during the month of April 1963. Abritrarily referenced by *Radiological Health Data* as test number 102, this test of low yield range was conducted underground at the Nevada Test Site on April 5. (Low yield range has been announced as being less than 20 kilotons yield.)

RADIOLOGICAL HEALTH DATA

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JUNE 1963

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

SECTION I.—AIR AND FALLOUT

Fission Product Beta Activity in Airborne Particulates and Precipitation

Quick and sensitive detection of fission product activity fluctuations in the environment is possible through a program of continuous surveillance of gross beta activity in air and precipitation. The information obtained through surveillance does not by itself permit evaluation of biological effects due to fallout, but it does form the basis of an alerting system and can be used as a rough guide for determining when and where more extensive monitoring of radioactivity in food, milk, and water is desirable.

February 1963 gross beta concentrations are presented here in reports from the Radiation Surveillance Network, Canadian Radioactive Fallout Study Program, and the Mexican Radioactive Fallout Program. Because of differences in equipment and techniques, the results from one network are not directly comparable with those of another. However, some intercalibration factors have been determined in a study conducted by Lockhart and Patterson of the U.S. Naval Research Laboratory (*1*, *2*). An application of the results of this study is presented in figure 3 in which the February gross beta radioactivity in air data from Canada and the U.S. were combined in one isogram map. To adjust to a common baseline, the U.S. data were multiplied by a factor of 1.54, the U.S.-Canadian intercalibration factor suggested by the NRL study.

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(*1*) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: *Intercalibration of Some Systems Employed in Monitoring Fission Products in the Atmosphere, NRL Report 5850*, Washington, D.C. (November 13, 1962).

(*2*) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: Intercalibration of Some Air Monitoring Systems, *Radiological Health Data*, *3*:466–70, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (December 1962).

RADIATION SURVEILLANCE NETWORK
February 1963

Division of Radiological Health,
Public Health Service

The Radiation Surveillance Network (RSN) comprises 72 sampling stations distributed among the fifty States, Guam, and Puerto Rico (see figure 1). These stations are manned predominantly by State health department personnel.

Air

Daily 24-hour air samples are collected on a 4-inch diameter, carbon-loaded cellulose dust filter in a high-volume air sampler. Field estimates of the gross beta activity of airborne particulates are derived by comparing portable survey meter readings of these filters with readings taken from a Sr^{90}–Y^{90} known activity source. This determination is usually made about 5 hours after the end of collection to eliminate interference from naturally occurring radon daughters. The network's station operators contribute to a daily national report by telephoning their field estimates to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C.

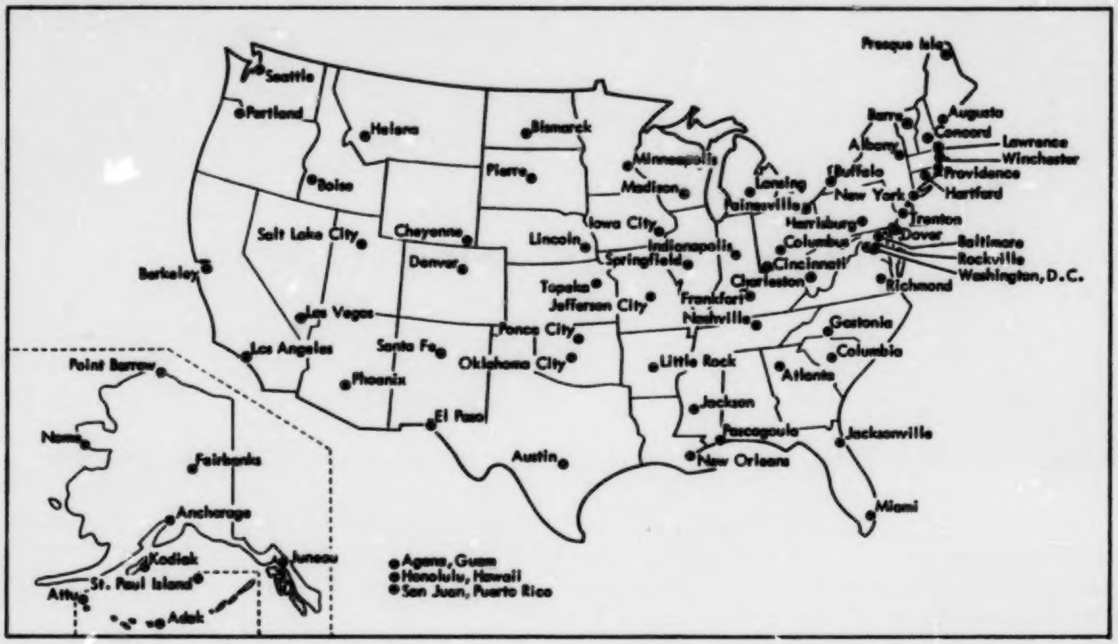
Presque Isle
Seattle
Portland
Helena
Bismarck
Augusta
Barre
Concord
Albany
Lawrence
Winchester
Minneapolis
Providence
Pierre
Lansing
Buffalo
Boise
Madison
Hartford
Painesville
New York
Iowa City
Trenton
Harrisburg
Salt Lake City
Cheyenne
Lincoln
Indianapolis
Dover
Columbus
Baltimore
Rockville
Berkeley
Denver
Springfield
Cincinnati
Washington, D.C.
Charleston
Richmond
Topeka
Jefferson City
Frankfort
Nashville
Las Vegas
Ponca City
Gastonia
Los Angeles
Santa Fe
Oklahoma City
Little Rock
Columbia
Point Barrow
Atlanta
Phoenix
Jackson
El Paso
Nome
Pascagoula
Jacksonville
Fairbanks
Austin
New Orleans
Miami
Anchorage
Kodiak
Juneau
Agana, Guam
Honolulu, Hawaii
San Juan, Puerto Rico
St. Paul Island
Attu
Adak

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS, FEBRUARY 1963

The filters are then forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, for a more refined measurement using a thin-window gas-flow proportional counter. Each filter is counted at least 3 days after the end of the sampling period and re-counted 7 days later. The initial 3-day aging of the sample eliminates interference from naturally occurring radon and thoron daughters. From the two counts separated by a 7-day interval, it is possible to estimate the age of fission products and to extrapolate the activity to the time of collection. The extrapolation is performed by using the Way-Wigner formula ($AT^{1.2} =$ constant).* The daily concentrations and estimated age are reported by the PHS in a monthly RSN report (*1*).

The average fission-product beta concentrations in surface air during February 1963, as determined by laboratory analysis and extrapolated to the time of collection, are given in table 1.

In order to compare these data with the gross beta reported by Canada, an adjustment is required. The relationship given by Lockhart and Patterson[1] is

$$\frac{\text{PHS}}{\text{Canada}} = 0.65 \pm 0.048 \text{ (one standard deviation)}$$

which may be written:

$$1.54 \times \text{PHS} \pm 7.4 \text{ percent} = \text{Canada}$$

It was considered more appropriate to adjust the RSN values upward to correspond with Canada's rather than to adjust the Canadian data downward. This was done in consideration of the higher filter efficiency and lower self-absorption of the Canadian system compared with that of the RSN.[1]

The Canadian air data and the adjusted RSN data have been combined in the map (figure 3), which includes most of the North American continent.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis using

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* In this expression, A is the activity and T is the time after fission product formation.

[1] See references (*1*) and (*2*), page 277.

TABLE 1.—GROSS BETA ACTIVITY OF PARTICULATES IN AIR, RSN, FEBRUARY 1963

[Concentrat..ns in μμc/m³]

Station location		Number of samples	Maximum	Minimum	Average[a]
Alaska:	Adak	28	13	0.35	4.8
	Anchorage	28	10	0.76	4.8
	Attu	28	19	0.76	5.7
	Fairbanks	23	5.3	0.99	3.7
	Juneau	18	12	0.11	3.8
	Kodiak	26	28	0.19	6.0
	Nome	25	10	0.27	3.9
	Point Barrow	28	7.6	0.91	4.2
	St. Paul Island	22	7.4	0.52	4.3
Ariz:	Phoenix	25	17	3.8	9.0
Ark:	Little Rock	26	12	3.0	8.3
Calif:	Berkeley	28	9.0	1.1	3.4
	Los Angeles	18	13	2.1	6.9
Colo:	Denver	27	18	3.3	8.5
Conn:	Hartford	28	8.3	1.7	5.4
Del:	Dover	20	11	1.5	7.8
D.C:	Washington	28	8.0	2.2	4.9
Fla:	Jacksonville	28	13	1.5	6.9
	Miami	27	12	1.3	6.5
Ga:	Atlanta	24	7.8	0.61	4.8
Guam:	Agana	11	11	0.16	1.9
Hawaii:	Honolulu	28	9.0	0.24	4.0
Idaho:	Boise	27	17	1.1	7.5
Ill:	Springfield	27	11	3.1	6.2
Ind:	Indianapolis	27	9.5	3.2	6.1
Iowa:	Iowa City	27	10	2.7	5.0
Kans:	Topeka	28	9.2	0.84	5.1
Ky:	Frankfort	28	11	3.3	6.5
La:	New Orleans	28	15	2.9	6.9
Maine:	Augusta	28	10	2.8	6.7
	Presque Isle	23	6.7	3.1	4.8
Md:	Baltimore	18	12	3.0	6.7
	Rockville	12	7.6	3.2	4.9
Mass:	Lawrence	28	9.3	3.4	5.6
	Winchester	25	16	5.1	9.3
Mich:	Lansing	28	12	4.3	7.6
Minn:	Minneapolis	28	7.1	2.8	4.7
Miss:	Jackson	25	12	2.7	6.7
	Pascagoula	19	11	2.7	6.9
Mo:	Jefferson City	28	11	2.1	5.7
Mont:	Helena	27	18	1.7	7.1
Nebr:	Lincoln	8	6.8	2.2	4.0
Nev:	Las Vegas	26	24	2.2	12
N.H:	Concord	17	12	6.0	9.4
N.J:	Trenton	28	8.6	2.7	5.4
N.Mex:	Santa Fe	28	11	0.84	5.7
N.Y:	Albany	28	9.5	<0.10	5.1
	Buffalo	28	13	3.0	6.5
	New York	13	6.3	2.1	3.9
N.C:	Gastonia	28	16	3.2	9.3
N.Dak:	Bismarck	28	7.9	1.5	5.1
Ohio:	Cincinnati	20	9.3	3.3	6.1
	Columbus	28	11	3.1	6.5
	Painesville	26	12	3.8	7.4
Okla:	Oklahoma City	27	9.6	0.78	5.4
	Ponca City	25	7.2	0.47	3.5
Ore:	Portland	26	26	1.2	10
Pa:	Harrisburg	11	8.2	3.6	5.8
P.R:	San Juan	26	5.3	0.85	2.7
R.I:	Providence	28	9.8	1.9	6.6
S.C:	Columbia	25	12	1.9	5.6
S.Dak:	Pierre	28	8.1	1.4	4.8
Tenn:	Nashville	25	13	1.1	7.4
Tex:	Austin	28	14	1.4	8.0
	El Paso	26	14	1.3	7.5
Utah:	Salt Lake City	28	22	2.5	8.9
Vt:	Barre	27	13	0.82	7.7
Va:	Richmond	28	8.2	2.4	5.1
Wash:	Seattle	28	14	0.59	4.8
W.Va:	Charleston	27	10	2.9	5.8
Wisc:	Madison	27	14	3.9	7.4
Wyo:	Cheyenne	28	16	0.64	6.7
Network average					6.1

[a] Weighted average obtained by summing the products of individual sampling times and the corresponding activities, and dividing by the summation of the individual sampling times.

TABLE 2.—GROSS BETA ACTIVITY IN PRECIPITATION, RSN, FEBRUARY 1963

Station location		Average concentration (μμc/liter)	Total deposition (mμc/m²)
Alaska:	Adak	[a]—	—
	Anchorage	3,300	59
	Attu	—	—
	Fairbanks	2,200	8.4
	Juneau	—	—
	Kodiak	—	—
	Nome	—	—
	Point Barrow	—	—
	St. Paul Island	—	—
Ariz:	Phoenix	—	—
Ark:	Little Rock	1,200	48
Calif:	Berkeley	730	77
	Los Angeles	900	73
Colo:	Denver	—	—
Conn:	Hartford	1,300	83
Del:	Dover	—	—
D.C:	Washington	1,600	80
Fla:	Jacksonville	1,400	130
	Miami	930	72
Ga:	Atlanta	550	46
Guam:	Agana	—	—
Hawaii:	Honolulu	—	—
Idaho:	Boise	1,100	65
Ill:	Springfield	2,300	29
Ind:	Indianapolis	2,600	30
Iowa:	Iowa City	1,200	7
Kans:	Topeka	—	—
Ky:	Frankfort	1,700	36
La:	New Orleans	1,100	169
Maine:	Augusta	900	96
	Presque Isle	—	—
Md:	Baltimore	—	—
	Rockville	—	—
Mass:	Lawrence	1,000	67
	Winchester	1,900	130
Mich:	Lansing	—	—
Minn:	Minneapolis	2,700	25
Miss:	Jackson	870	37
	Pascagoula	—	—
Mo:	Jefferson City	690	0.6
Mont:	Helena	3,400	43
Nebr:	Lincoln	—	—
Nev:	Las Vegas	—	—
N.H:	Concord	—	—
N.J:	Trenton	6,800	13
N.Mex:	Santa Fe	2,600	81
N.Y:	Albany	720	24
	Buffalo	—	—
	New York	—	—
N.C:	Gastonia	750	46
N.Dak:	Bismarck	2,000	18
Ohio:	Cincinnati	—	—
	Columbus	5,100	16
	Painesville	2,500	20
Okla:	Oklahoma City	—	—
	Ponca City	—	—
Ore:	Portland	1,500	110
Pa:	Harrisburg	—	—
P.R:	San Juan	500	19
R.I:	Providence	2,200	160
S.C:	Columbia	1,700	190
S.Dak:	Pierre	—	—
Tenn:	Nashville	2,500	140
Tex:	Austin	1,200	88
	El Paso	7,700	29
Utah:	Salt Lake City	2,200	30
Vt:	Barre	1,500	69
Va:	Richmond	920	56
Wash:	Seattle	1,800	110
W.Va:	Charleston	1,200	24
Wisc:	Madison	1,700	8.1
Wyo:	Cheyenne	—	—

[a] Dash indicates no evaporated sample received.

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funnels with collection areas of 0.4 square meters. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory to be counted by the same method used for analyzing the air sample, including extrapolation to the time of collection. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of preciptiation is reported, but no analysis is made. February 1963 averages of gross beta activity in precipitation, expressed in micromicrocuries per liter ($\mu\mu$c/liter) and millimicrocuries per square meter (mμc/m^2), are presented in table 2.

(1) Radiation Surveillance Network: *Monthly Tabulation of Findings*, Division of Radiological Health, Public Health Service, Washington 25, D.C. (Distribution by official request).

CANADIAN RADIOACTIVE FALLOUT STUDY PROGRAM

February 1963

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program (RFSP), the Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation at 24 stations located at airports (see figure 2). The sampling equipment is operated by meteorologists of the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the Radioactive Fallout Study Program are contained in the Department's reports (*1–5*).

Air

In the collection of air samples, about 650 cubic meters of air are drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is removed from each filter and counted with a thin-end-window Geiger flow counter system, calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to allow for the presence of natural activities and for the decay of short-lived fission products. The result is extrapolated to the end of the sampling period. Canadian air data for February 1963 are given in table 3, and presented in conjunction with U.S. adjusted air data in the concentration contour map (figure 3).

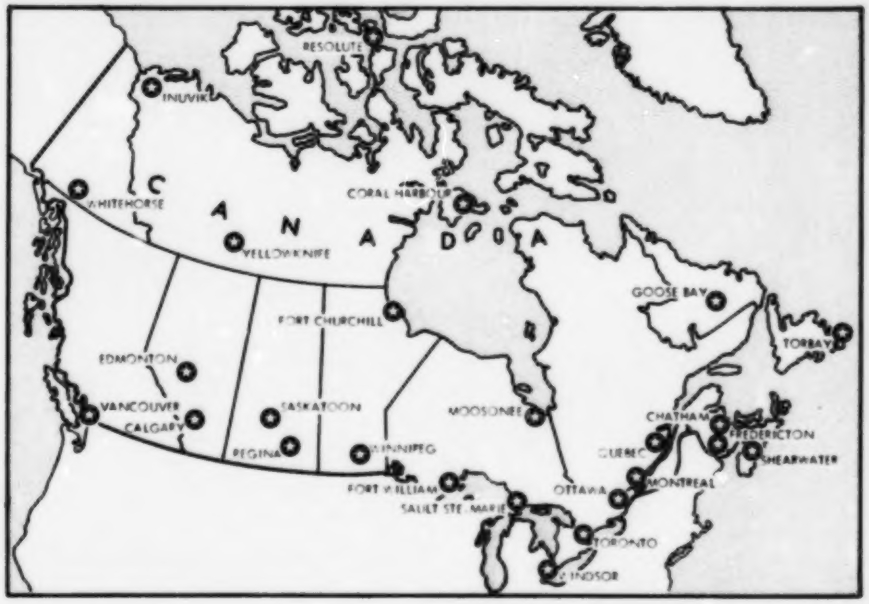

FIGURE 2.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS, FEBRUARY 1963

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN AIR, RFSP, FEBRUARY 1963

[Average concentrations in $\mu\mu c/m^3$]

Station	Number of samples	Maximum	Minimum	Average
Calgary	28	24.0	0.7	9.8
Coral Harbour	28	23.0	0.1	7.7
Edmonton	21	12.3	2.5	6.5
Ft. Churchill	28	12.5	0.4	5.6
Ft. William	28	17.3	6.5	10.7
Fredericton	27	13.8	2.9	9.8
Goose Bay	27	12.0	0.8	6.9
Inuvik	28	16.0	5.3	10.1
Montreal	27	16.3	4.8	10.6
Moosonee	26	23.3	4.7	10.3
Ottawa	28	16.5	6.1	11.3
Quebec City	28	15.3	6.2	10.5
Regina	28	16.7	4.2	10.7
Resolute	22	16.5	0.6	8.4
Saskatoon	27	19.0	7.2	11.2
Sault Ste. Marie	28	21.0	7.6	11.0
Shearwater	26	18.6	6.3	13.0
Torbay	26	20.0	1.4	9.1
Toronto	28	22.0	1.1	11.1
Vancouver	28	22.0	0.8	6.3
Whitehorse	27	15.8	0.7	8.0
Windsor	27	28.0	7.4	12.8
Winnipeg	28	21.5	6.8	11.6
Yellowknife	28	19.5	5.0	10.9
Average				9.8

Precipitation

The amount of radioactive fallout being deposited on the ground is determined from measurements on material collected in special polythene-lined rainfall pots. After transfer of the water to the sampling container, the polythene liner is removed, packed with the sample, and sent to the laboratory. February 1963 precipitation data for Canada, including some radiochemical analyses, are shown in table 4.

REFERENCES

(1) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1959 on the Radioactive Fallout Study Program, CNHW (RP-3)*, (May 1960).

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(3) Mar, P. G.: *Annual Report for 1961 on the Radioactive Fallout Study Program CNHW (RP-5)*, (June 1, 1960).

(4) Beale, J. and J. Gordon: *The Operation of the Radiaiion Protection Division Air Monitoring Program, (RPD-11)*, (July 1962).

(5) Booth, A. H.: *The Calculation of Maximum Permissible Levels of Fallout in Air and Water and Their Use in Assessing the Significance of 1961 Levels in Canada, (RPD-21)*, (August 1962).

Recent coverage in *Radiological Health Data:*

Period	Issue
Third quarter 1961	*May 1962*
Fourth quarter 1961	*September 1962*
First quarter 1962	*October 1962*
Second and third quarters 1962	*January 1963*
October 1962	*February 1963*
Novermber 1962	*March 1963*
December 1962	*April 1963*

TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, RFSP, FEBRUARY 1963

Station	Total beta activity		Deposition of specific radionuclides for selected samples[a, b] ($m\mu c/m^2$)				
	$\mu\mu c$/liter	$m\mu c/m^2$	Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ba^{140}
Calgary	1,278	10.4	1.87	0.13	1.14	0.07	0.27
Coral Harbour	—[c]	63.9					
Edmonton	3,148	72.0					
Ft. Churchill	6,808	24.2					
Fort William	2,316	37.1					
Fredericton	375	42.1					
Goose Bay	210	16.8					
Inuvik	2,683	27.3					
Montreal	2,452	144.4	15.1	0.87	22.0	2.04	2.84
Moosonee	537	21.5					
Ottawa	1,921	93.2					
Quebec	895	92.5					
Regina	2,453	30.5					
Resolute	2,177	199.0					
Saskatoon	1,442	38.4					
Sault Ste. Marie	1,006	68.0					
Shearwater	—	—					
Torbay	906	88.5					
Toronto	465	59.1					
Vancouver	2,300	331.0	39.4	1.80	45.1	3.40	5.18
Whitehorse	2,190	24.5					
Windsor	3,114	65.7					
Winnipeg	1,599	51.2	4.88	0.51	9.55	0.48	0.84
Yellowknife	2,844	35.4					
Average	1,960	71.2					

[a] All values corrected for decay back to end of collection month.

[b] Values for strontium-90, cesium-137, and zirconium-95 do not include the activities of their daughter isotopes, yttrium-90, barium-137, and niobium-95.

[c] Dash indicates no sample.

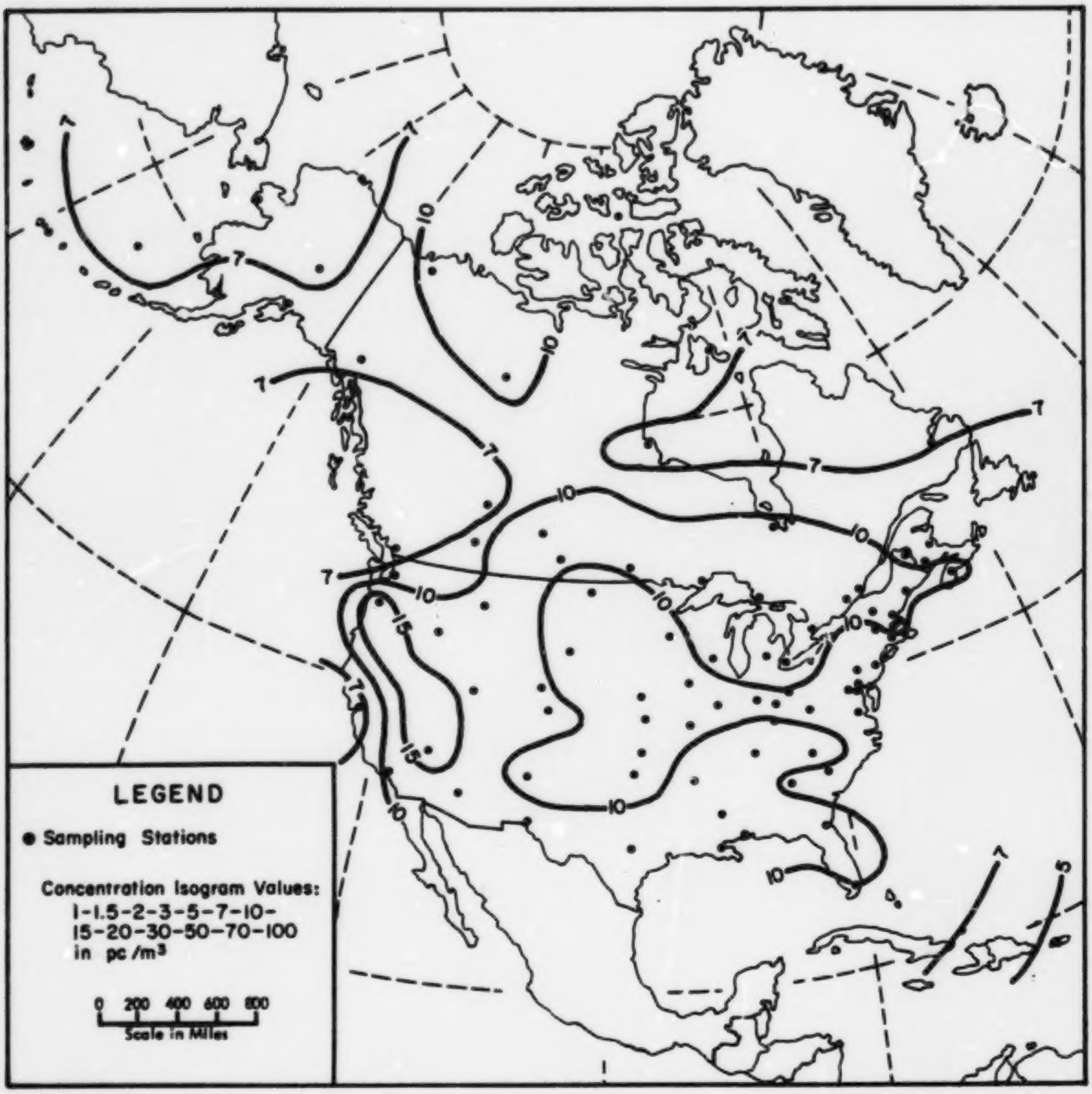
LEGEND
● Sampling Stations
Concentration Isogram Values:
1-1.5-2-3-5-7-10-
15-20-30-50-70-100
in pc/m³
0 200 400 600 800
Scale in Miles
7
10
15
5

FIGURE 3.—AIRBORNE GROSS BETA CONCENTRATION ISOGRAMS FOR CANADA AND THE U. S., FEBRUARY 1963

MEXICAN RADIOACTIVE FALLOUT PROGRAM
February 1963

Radiological Protection Program
National Commission of Nuclear Energy, Mexico

The Radiation Surveillance Network of Mexico was established by the Comisíon Nacional de Energía Nuclear (CNEN) through its Radiological Protection Program (RPP) in 1961 to provide a means for determining increased levels of radioactivity in air and precipitation due to fallout from nuclear tests.

Prior to the establishment of the network, two pilot sampling stations were set up in Mexico City and San Luis Potosí to aid in the selection of equipment and sampling sites. Since April 1962 the network has been expanded to twelve stations (see figure 4).

Eight of the twelve stations are located at airports and operated by airline personnel. The remaining four stations are located at Mexico City, Mérida, Veracruz, and San Luis Potosí. Staff members of the RPP operate the station at Mexico City, while the other three stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, and the Instituto de Zonas Desérticas of the University of San Luis Potosí, respectively.

In December 1962, the station located in Tijuana was moved to Ensenada, a city on the Pacific Coast 60 miles from Tijuana, where it is operated by the staff members of the Escuela Superior de Ciencias Marinas of the University of Baja California.

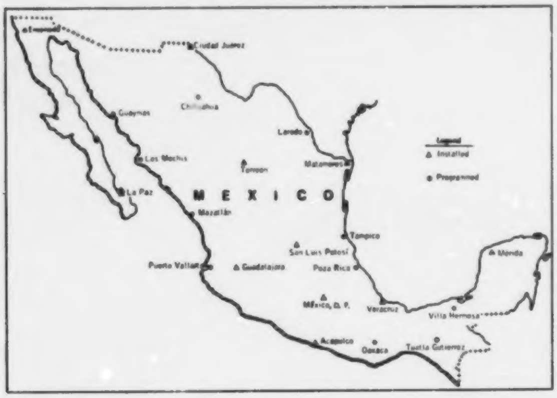

FIGURE 4.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

Sampling

The sampling procedure involves drawing air 24 hours a day, 3 or 4 days a week at the rate of approximately 1,200 cubic meters per day, through a 6″ x 8″ high-efficiency glass fiber filter, using high-volume samplers. After each 24-hour period, the filter is removed and airmailed to the Laboratorio de Desechos Radiactivos (CNEN) in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughters. Data are not extrapolated to time of collection.

The maximum, minimum, and average fission-product beta concentrations in surface air during February 1963 are presented in table 5.

TABLE 5.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, FEBRUARY 1963

[Concentrations in $\mu\mu c/m^3$]

Station	Number of samples	Maximum	Minimum	Average
Acapulco*				
Ciudad Juárez	5	26.2	3.5	19.7
Ensenada	2	16.3	0.9	—
Guadalajara	4	23.6	2.1	10.6
La Paz	19	14.1	1.3	6.8
Mérida	7	17.8	6.3	10.6
México, D. F.**	14	34.1	2.0	13.5
San Luis Potosí	11	38.5	4.1	12.5
Torreón	15	23.7	5.5	13.5
Tuxtla Gutierrez	15	21.3	0.7	4.8
Veracruz	19	41.6	0.7	10.4

* Out of order.
** Mexico City.

SECTION II.—FOOD

Radionuclides in Diets For Teen-agers

May 1962–February 1963

Division of Pharmacology, Food and Drug Administration

It has been estimated that among all age groups 16-19-year-old males need more food daily than any other segment of the U.S. population (*1*). Because of this, the Food and Drug Administration (FDA) chose this age group for a test of the maximum radionuclide intake of all population groups. As a basis for the test, the food plan used was that recommended by the U.S. Department of Agriculture (USDA) for a nutritionally adequate diet at moderate cost level for boys 16-19 years of age (*2*).

The FDA study of radionuclides in diets for teen-agers was begun on a pilot basis in May 1961 in the Washington, D.C., area. Since then, the program has been expanded to include 4 other cities—San Francisco, Minneapolis, St. Louis, and Atlanta. Samplings are being made quarterly.

By selecting the 16-19-year-old male, who daily needs 3,600 calories well-laced with protein, minerals, and vitamins, compared with 3,200 calories and smaller amounts of nutrients needed by the "standard" man, the radionuclide intake in U.S. diets can be conservatively estimated. For the purposes of the sampling program, amounts of the detailed foods selected from the 11 food groups of the USDA plan were proportioned according to the 1955 Household Food Consumption Survey (*3*).

Procedures

To duplicate the diet of a 19-year-old male, a list of 82 different items of food and drink was prepared. The amounts of these items, covering a two-week consumption period, were purchased from national food chain stores. Among the food sources sampled the variation of radionuclide concentration within a particular food was found to be statistically insignificant. Every effort was made to locate the source of the food items and arrange representation in the sample on as broad a geographical basis as possible.

The food was prepared by professional dietitians at the National Institutes of Health in a manner comparable to domestic preparation procedure. The most acceptable home practices for washing, trimming, bone removal, and separation of wastes and cooking water were used. Meats, fish, and chicken were broiled before removing the bones. Some fruits and vegetables were prepared as raw servings while others were cooked. Canned foods and raw frozen fruits were used as is. Coffee and tea were brewed. Certain cereals, such as rice and oatmeal, and macaroni were cooked in water. Representative portions of each food (including drinking water) were homogenized into a slurry, and aliquots were analyzed for strontium-90.

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TABLE 1.—STRONTIUM-90 CONCENTRATIONS IN THE TOTAL DIET (INCLUDING DRINKING WATER)

Sampling locations	May 1963		August 1962		November 1962		February 1963	
	pc/kg	pc/day*	pc/kg	pc/day*	pc/kg	pc/day*	pc/kg	pc/day*
San Francisco, Calif.	3.0	11.3	3.4	12.8	4.8	18.1	8.0	30.1
Washington, D. C.	6,4	24.0	6.9	26.0	8.4	31.6	12.0	45.1
Atlanta, Ga.	9.7	36.4	7.2	27.1	9.2	34.6	12.5	47.1
Minneapolis, Minn.	5,2	19.5	9.0	33.8	7.9	29.7	8.8	33.1
St. Louis, Mo.	10.0	37.6	8.8	33.1	9.5	35.7	7.1	26.7

* Estimated intake for the 19-year age group.

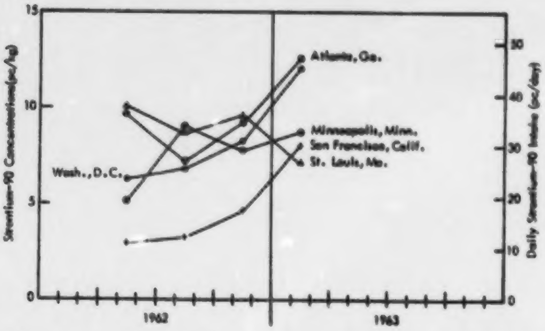

FIGURE 1.—STRONTIUM-90 CONCENTRATIONS IN THE TOTAL DIET (INCLUDING DRINKING WATER)

The average strontium-90 concentrations in the diet for the five cities surveyed are presented in table 1. Through reanalysis of some samples, data previously presented in *Radiological Health Data* have been corrected. All confirmed values are presented in table 1. These data are presented graphically in figure 1.

Discussion

Since May 1962, and extending throughout 1962, strontium-90 concentrations have ranged between 3 and 10 pc/kg of food. Notable is the fact that San Francisco had the lowest values.

All cities except St. Louis showed an increase in strontium-90 concentrations in February 1963 over the November 1962 values. Percentagewise, the largest increases from November to February were in Atlanta, Washington, D.C., and San Francisco.

Using a consumption factor of 3.76 kilograms/day, it is apparent that the daily intake of strontium-90 at Atlanta for February 1963 was 47 pc/day. This is the largest intake at any of the five cities at any time since the beginning of this program in May 1962 and represents about 25 percent of the Federal Radiation Council Range II maximum for strontium-90 of 200 pc/day.

Previous coverage in *Radiological Health Data:*

Period	Issue
May–August 1962	*January 1963*

REFERENCES

(*1*) The National Academy of Sciences—National Research Council: *Recommended Dietary Allowances*, National Research Council Publication 589, Revised (1958).

(*2*) U.S. Department of Agriculture: *Family Food Plans and Food Costs, Home Economics Research Report No. 20*, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (November 1962), price $.35.

(*3*) U.S. Department of Agriculture: *Food Consumption of Households in the United States, Report No. 1 (1955)*, Household Food Consumption Survey. Superintendent of Documents, Government Printing Office, Washington 25, D.C. (December 1956), price $1.00.

Strontium-90 in Canadian Wheat, 1957-1961[1]

H. Taniguchi[2]

A comprehensive program for the measurement of strontium-90 in Canadian wheat was started in 1959 by the Radiation Protection Division of the Canadian Department of National Health and Welfare, with the assistance of the Department of Trade and Commerce and Atomic Energy of Canada Limited. The actual sampling for the program was planned and carried out by the Grain Research Laboratory and the Grain Inspection Branch of the Board of Grain Commissioners for Canada.

The major wheat growing areas for hard red spring wheat were divided into nine districts as shown in figure 1.

At the end of a crop year, ten pounds of wheat were obtained from each district. Each sample was a composite of a large number of smaller samples obtained within a district, weighted according to production, and was closely representative of all wheat produced in that district.

Method of Analysis

The method of analysis and results for a variety of samples of stored wheat from the 1957 and 1958 crop years and of wheat exported from the Pacific and Atlantic seaboard ports have been reported from the Low Level Laboratory of Atomic Energy of Canada Limited at Deep River, Ontario, by Grummitt and Robertson (*1*).

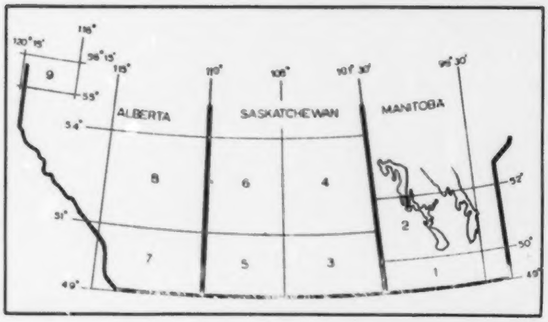

FIGURE 1.—WHEAT SAMPLING DISTRICTS OF CANADA

The method was adapted from the procedure used for strontium-90 determinations in milk (*2*, *3*). In most cases, 500 grams of each composite were taken. These samples, as received, were throughly heated at 200° C and dry-ashed at 600° C to a white residue. The resulting ash was leached with 6 N hydrochloric acid in the presence of strontium carrier. The strontium fraction was isolated by elution with 6 N hydrochloric acid from a cation exchange column after the calcium had been removed by eluting with ammonium lactate. Yttrium-90 resulting from this further purified strontium fraction was then separated and counted. The chemical recovery of strontium carrier was corrected for the natural strontium content of the sample, assuming an average correction of 3 percent (*1*). A portion of the hydrochloric acid leach was analyzed for calcium by double precipitation of the oxalate and titration of the oxalate with potassium permanganate in the presence of sulphuric acid.

Aliquots of samples of the 1959 crop year, which were collected under the present sampling arrangement, were analyzed in the laboratory of Atomic Energy of Canada Limited as well as in the Radiation Protection Division's laboratory to verify that the overall procedure was comparable. The average deviation of independent duplicate analyses in the Radiological Protection Division's laboratory was 1.1 $\mu\mu c$/kg wheat and the average deviation between the analyses in the two laboratories was 2.1 $\mu\mu c$/kg wheat with both positive and negative deviations. This is well within the 6 percent standard error found for similar analyses of milk powder (*4*).

Results and Discussion

The results of the analyses of whole wheat for the crop years 1959, 1960, and 1961 are presented in table 1. Strontium-90 values in wheat for the years 1957 through 1961 are presented graphically in figure 2. The estimated production figures, supplied by the Grain Research Laboratory, were used to calculate the reported weighted averages. Where there was a significant delay between sampling and analysis, the values were corrected

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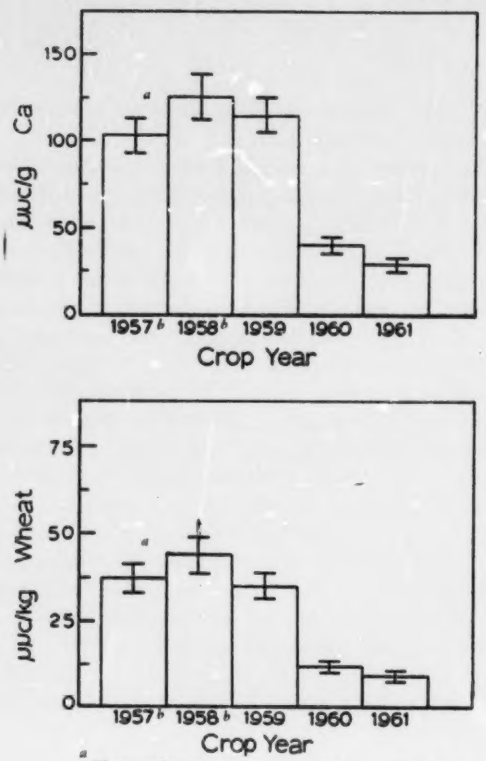
[1] Data abstracted from the *Annual Report for 1961 on the Radioactive Fallout Study Program, CNHW (RP-5)*, (December, 1962), of the Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada.

[2] Dr. Taniguchi is Radiochemist with the Radiation Protection Division of the Canadian Department of National Health and Welfare, 370 Sparks Street, Ottawa 4, Ontario, Canada.



[a] The error bars shown represent a 10 percent deviation which is estimated to be the standard error for the complete analytical procedure. Sampling error and other sources of uncertainty are not included.

[b] Values for 1957 and 1958 from A.E.C.L. Report CRER-1000 (1960).

FIGURE 2.—STRONTIUM-90 IN CANADIAN WHEAT

for decay of strontium-90 to September of the year in which the wheat was grown.

The values in table 1 show no appreciable differences in the strontium-90 content of Canadian wheat in 1959 as compared with 1957 or 1958. In 1957, the mean values of a composite representing production for that year were 103 ± 10 μμc/g calcium and 37 ± 4 μμc/kg wheat, and in 1958 the corresponding figures were 125 ± 13 μμc/g calcium and 44 ± 5 μμc/kg wheat (*1*). During 1959, the weighted average strontium-90 values were 114 μμc/g calcium and 35 μμc/kg wheat. Within the limits of the analytical error, this change is not significant.

However, the strontium-90 level in wheat harvested during 1960 fell to a value of 40.8 μμc/g calcium and 12.0 μμc/kg wheat, or about one-third of the previous year's values. In 1961, there was a further decrease, as the value fell to 29 μμc/g calcium and 9.5 μμc/kg wheat. One anomaly was noted; unlike the other districts, district 7 showed an increase in 1961 over 1960 (when the strontium-90 activity is expressed as μμc/kg of wheat). However, the increase was small (14 percent) and indeed, when the levels are expressed in μμc/gram of calcium, the 1961 value is found to be less than that of 1960 for the district 7 sample as well.

The overall decrease in the amounts of strontium-90 found in wheat, in spite of the gradual increase of strontium-90 deposited on the soil, may be attributed to two factors. One factor may be a "fixation" of strontium-90 in soil minerals, thus making it progressively less available to the growing plant. The other factor may be the ability

TABLE 1.—STRONTIUM-90 AND CALCIUM IN CANADIAN WHEAT, 1959–1961

Identification of data	Year	Districts									Calculated weighted mean
		1	3	5	7	2	4	6	8	9	
		Latitude									
		49–50°	49–50°			50–52°	51–54°			55–60°	
Strontium-90 (pc/g Ca)	1959	121	64	54	114	119	129	108	185	114	114
	1960	46	31	27	36	44	40	37	69	47	40.8
	1961	20	17	19	34	15	15	21	54	44	29.3
Strontium-90 (pc/kg wheat)	1959	33	20	18	37	34	39	37	57	30	35.2
	1960	11	8	10	12	12	11	12	21	13	12.0
	1961	6	6	7	13	6	5	7	17	13	9.5
Calcium (mg/kg wheat)	1959	272	316	332	322	288	304	334	306	266	310
	1960	250	260	360	318	264	284	327	308	273	295
	1961	306	329	367	384	368	340	347	310	260	333
Production (in millions of bushels rounded).	1959	33.8	50.4	35.5	35.0	17.9	70.7	47.8	51.6	7.4	[a]350.0
	1960	34.7	93.5	46.0	22.5	18.5	68.2	64.8	58.4	7.4	[a]414.4
	1961	16.9	22.2	13.4	16.0	8.2	21.8	34.5	44.2	9.2	[a]186.4

[a] Total.

of the aboveground parts of the wheat plant to absorb fallout elements directly, rather than through the root system. The amount found in the harvested grain probably depends upon the rate of deposition of fallout during the period of growth as well as upon the accumulated strontium-90 in the soil.

It must be emphasized that the reported values are for whole wheat, not wheat flour. This is significant because much of the strontium-90 is in the bran fraction. For example, Grummitt and Robertson (*1*) found that the amount of strontium-90 in white flour milled from wheat harvested in 1957 and 1958 was less than that in whole wheat by a factor of 8 on a weight basis (a factor of 3.3 relative to calcium). The corresponding ratios between bran and flour from wheat harvested in other years are not available.

Acknowledgments

The collection and composition of the samples were arranged by Dr. J. A. Anderson, of the Grain Research Laboratory, Winnipeg. The advice and assistance received from Dr. W. E. Grummitt and G. Lahaie, of Atomic Energy of Canada Limited, in the radiochemical analyses are gratefully acknowledged. The analyses in the Radiation Protection Division Laboratory were carried out by G. E. Holmes and J. M. Quinn.

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(*1*) Grummitt, W. E., and E. R. Robertson: *Strontium-90 and Cesium-137 in Canadian Wheat, 1957–1959, Atomic Energy of Canada Limited, Report CRER–1000* (1960).

(*2*) Grummitt, W. E., and Gwen M.Milton: *Radiochemical Procedures for Strontium and Yttrium, Atomic Energy of Canada Limited, Report CRC–688* (1957).

(*3*) Mar, P. G.: *Outline of Procedure for the Radiochemical Analysis of Dried Milk Powder for Strontium and Yttrium, Department of National Health and Welfare, Report RPD–5* (1960).

(*4*) Grummitt, W. E., A. P. James, and H. B. Newcombe: *The Analysis of Strontium-90 Levels in Canadian Milk Up to 1958, Atomic Energy of Canada Limited, Report CRC–850* (1959).

Tri-City Diet Study[*]

August–September 1962

Joseph Rivera
Health and Safety Laboratory, U.S. Atomic Energy Commission

Since March 1960 the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium-90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods, representing 19 food categories, are purchased at each of these three cities about every 3 months and are analyzed for strontium-90. Using data from the U.S. Department of Agriculture, "Household Food Survey of 1955," the annual consumption by an average individual can be grouped into the same 19 food categories. The annual dietary intake of strontium-90 can be estimated by summing the contributions from each category. Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general.

The consumption data from the "Household Food Survey of 1955" are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is de-boned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the wasted food.

After two samplings at each city it was found that the calcium content of most food categories did not vary among cities nor did it vary significantly with time. Calcium analyses were therefore discontinued and average calcium content of foods was computed and used to estimate the average annual intake of this mineral. The specific numbers used to calculate calcium intake are given in HASL-113 (*1*).

Results obtained from the tenth sampling of foods (August–September 1962) are presented in table 1. The variation with time of the daily intake of strontium-90 in the three cities is plotted in figure 1.

Discussion

The strontium-90 concentration of milk obtained in New York City during June 1962

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[*] *Fallout Program Quarterly Summary Report, HASL–135:* 269–272, Office of Technical Services, Department of Commerce, Washington 25, D.C. (April 1, 1963), price $3.50.

TABLE 1.—AVERAGE PERSON DIETARY CONSUMPTION AND STRONTIUM-90 INTAKE—TENTH SAMPLING

Food category	Average U. S. consumption		New York City August 1962		Chicago October 1962		San Francisco September 1962	
	kg/yr	Calcium (g/yr)	μμc/kg	μμc/yr	μμc/kg	μμc/yr	μμc/kg	μμc/yr
Bakery products	37	37.0	9.4 ± 0.7	346	22.0 ± 1.1[a]	813	6.7 ± 0.9[a]	248
Whole grain products	11	10.0	14.1 ± 1.0	155	17.0 ± 1.3	187	11.0 ± 1.2	121
Eggs	16	9.1	1.3 ± 0.1	20	5.3 ± 0.2	85	2.6 ± 0.1	202
Fresh vegetables	43	15.0	9.3 ± 0.4	398	12.0 ± 0.4	514	2.2 ± 0.5	95
Root vegetables	17	6.1	7.1 ± 0.5	121	4.9 ± 0.2	83	2.1 ± 0.3	36
Milk	221	234.3	16.2 ± 0.5	3,580	7.6 ± 0.4	1,670	3.4 ± 0.4	751
Poultry	17	9.2	0.8 ± 0.1	13	2.1 ± 0.1	36	1.7 ± 0.2	29
Fresh fish	8	10.8	0.3 ± 0.1	2	1.8 ± 0.2	14	0.9 ± 0.4	7
Flour	43	8.6	4.5 ± 0.2	195	14.8 ± 0.3	635	4.8 ± 0.3	206
Macaroni	3	0.7	4.6 ± 0.2	14	8.5 ± 0.3	25	3.8 ± 0.3	11
Rice	3	1.1	1.5 ± 0.3	5	3.0 ± 0.4	9	0.8 ± 0.4	2
Meat	73	10.9	0.7 ± 0.1	52	6.7 ± 0.1	488	1.0 ± 0.1	73
Shellfish	1	0.8	2.8 ± 1.7	3	6.6 ± 0.1	7	0.9 ± 0.2	1
Dried beans	3	2.9	2.4 ± 1.2	7	16.8 ± 1.7	50	7.0 ± 1.4	21
Fresh fruit	68	13.6	1.9 ± 0.3	129	4.6 ± 0.4	316	0.5 ± 0.3	34
Potatoes	45	5.8	5.5 ± 0.6	249	1.9 ± 0.4	87	4.4 ± 0.5	198
Canned fruit	26	1.3	1.3 ± 0.1	32	0.5 ± 0.1	12	0.7 ± 0.1	18
Fruit juices	19	1.7	1.8 ± 0.1	34	3.9 ± 0.3	73	2.9 ± 0.4	55
Canned vegetables	20	4.2	3.7 ± 0.2	75	7.7 ± 0.5	154	1.0 ± 0.5	20
Annual intake	674	383		5,430		5,258		2,128
μμc Sr^{90}/g Ca in total diet				14.1		13.7		5.6

[a] Values are one standard deviation errors due to counting.

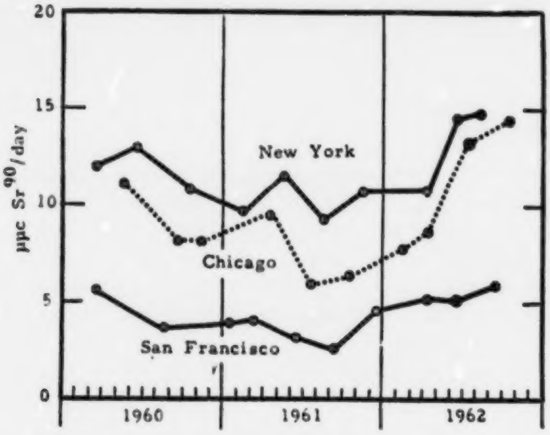

FIGURE 1.—DAILY INTAKE OF STRONTIUM-90 IN TRI-CITY TOTAL DIETS

(*Radiological Health Data*, March 1963, page 130–1) has been revised on the basis of a re-analysis of the sample. The old value of 9.0 μμc/kg has been changed to 15.1 μμc/kg. This change requires the estimated annual intake of strontium-90 in New York City for June 1962 to be changed from 4,029 to 5,380 μμc (11.0 μμc/day to 14.7 μμc/day). Comparing this revised estimate of intake with the calculated intake from the August sampling of foods, we see that there was no increase in the estimated intake of strontium-90 at New York City between June and August 1962. This was not the case for Chicago and San Francisco, where increases of about 10 percent were noted in the estimated strontium-90 intakes between the ninth and tenth samplings.

The previously noted geographic pattern of distribution of strontium-90 in foods is seen to persist in the last sampling: New York City has the highest levels, San Francisco the lowest, while Chicago has intermediate livels. During this tenth sampling, New York City had the highest strontium-90 daily intake (14.9 μμc/day) that has been estimated for any of the cities since the tri-city diet surveys began.

Partly due to its high annual consumption, milk continues to be the predominant source of strontium-90 in the diet.

Recent coverage in *Radiological Health Data:*

Period	Issue
Fifth sampling (May–July 1961)	*March 1962*
Sixth sampling (August–October 1961)	*June 1962*
Seventh sampling (November 1961–February 1962)	*September 1962*
Eighth sampling (April 1962)	*January 1963*
Ninth sampling (June–July 1962)	*March 1963*

REFERENCE

(*1*) U.S. Atomic Energy Commission: *Fallout Program Quarterly Summary Report, HASL–113*, Office of Technical Services, Department of Commerce, Washington 25, D.C (July 1, 1961), price $2.50.

SECTION III.—MILK

Milk Surveillance

Milk is the single food item most often used as an indicator of the population's intake of radionuclides from the environment, although it is only one of the many sources of dietary intake of radionuclides. A number of factors account for its use as an indicator food. For example, milk is consumed by a large proportion of the U.S. population. It is produced on a regular basis throughout the country, and it is more easily sampled and analyzed than most other foods. Further, because milk tank trucks collect and pasteurizing plants process milk from a number of producers, milk subsamples from individual plants, when properly composited, are representative of the milk consumed in a marketing area, and the radionuclide concentrations of these composited samples are indicative of radionuclide fallout over the milk producing area.

PASTEURIZED MILK NETWORK
February 1963

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk radionuclide surveillance program had its origin in a 12-station raw milk monitoring network, which was established by the Service in 1957. One of the primary objectives of this earlier network was to develop methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a 46-station pasteurized milk sampling program in July 1960. The 46 stations were selected to provide general national coverage of milk production areas and the consuming population.

As further needs developed, more milk sampling points were added, up to July 1962, when the present number of 62 stations was reached. Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each of these stations. After collection, the composities are preserved with formaldehyde and are sent to the PHS Southwestern, Southeastern, and Northeastern Radiological Health Laboratories for analyses. Approximately 3–6 days after sample collection, any results from gamma analyses of iodine-131 which indicate concentrations of this radionuclide greater than 100 $\mu\mu c$/liter are made available to State public health officials and the Federal Radiation Council for possible public health action. Publication of the radioanalyses of milk in *Radiological Health Data* follows 3 to 4 months after sample collection because of the time required for shipment, processing, analysis of radiostrontium, data compilation and publication procedures.

Sampling and Compositing Prodecures

The method of compositing specifies that each station's sample be composited of subsamples

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from each milk processing plant in proportion to the plants sales in the communities served. The composited samples from each of the 62 stations reflects from 80 to 100 percent of the milk processed in each city. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in September 1961 and continuing through January 1963, sampling was done twice a week. During February 1963, sampling at most stations was reduced to once a week.

All surveillance data are subject to continuing review and evaluation to observe unusual patterns or concentrations which may require immediate attention. Further atmospheric nuclear testing may require re-evaluation and adjustment of the sampling frequency and analytical schedule for this program.

Analytical Errors

Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma scintillation spectroscopy,[1] while strontium-89 and strontium-90 concentrations are determined by radiochemical procedures. There is an inherent statistical variation associated with all measurement of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation is relatively high. The variation is dependent upon the method of chemical analysis, the counting rate and counting time, the interferences from other radionuclides, and the background counting rate. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 minutes for low background beta determinations are used. Table 1 shows the approximate total laboratory analytical error associated with different radionuclide concentrations in milk. The ± 2σ range about the measured concentration corresponds to a 95 percent certainty that the true concentration is within this range. The minimum detectable concentration is defined to be that concentration at which the 2σ analytical error is 100 percent. Therefore, the minimum detectable concentrations in units of μμc/liter are Sr^{89}, 5; Sr^{90}, 1; I^{131}, 10; Cs^{137}, 5; and Ba^{140}, 10.

Data Presentation

Table 2 presents a summary of all available analyses for February 1963 (January 27–February 23, 1963). When a laboratory reports that the concentration of a radiounuclide is below the minimum detectable value, one-half of this value is used in calculating the monthly average and the network average. Although no data are presented on stable potassium concentrations in milk, analyses have indicated that the usual range is from 1.4 to 1.7 grams/liter. In February, for example, 15, 23, 21 and 2 stations were reported to have respective monthly average potassium concentrations of 1.4, 1.5, 1.6, and 1.7 grams/liter of milk.

Figure 1 and 2 show the approximate occurrence of monthly U.S. average estimated strontium-89 and strontium-90 concentrations in milk. The value printed beside each station is the monthly average concentration for that station. Table 3 shows the numerical distribution of stations according to ranges of radionuclide concentrations in milk for February.

Discussion of Data

Of the 62 sampling stations, 42 showed monthly average concentrations of strontium-89 in milk for February 1963 of 20 μμc/liter or below (table 2). The Southeast, from South Carolina to Florida and west to eastern Texas, had strontium-89 concentrations of 50 to 200 μμc/liter (figure 1). Jackson, Mississippi, and New Orleans, Louisiana, had strontium-89 concentrations of 210 and 270 μμc/liter, respectively.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH TYPICAL CONCENTRATIONS OF SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (μμc/liter)	Error, ±2σ (percent of concentration)	Estimated concentration (μμc/liter)	Error, ±2σ (percent of concentration)	Estimated concentration (μμc/liter)	Error, ±2σ (percent of concentration)
Iodine-131	10	±100%	20	±50%	100	±10%
Barium-140	10	±100%	20	±50%	100	±10%
Cesium-137	5	±100%	10	±50%	100	±10%
Strontium-89	5	±100%	10	±50%	100	±10%
Strontium-90	1	±100%	2	±50%	20	±10%

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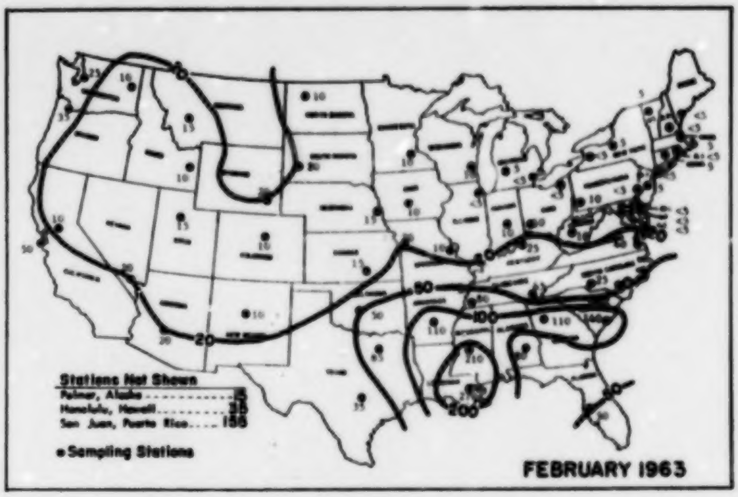
[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

In February, high monthly average strontium-90 concentrations in milk were noted in the same areas as they were in January. In general, levels in the Southwest were below 5 μμc/liter, while monthly averages in the east ranged from 20 to 36 μμc/liter (figure 2).

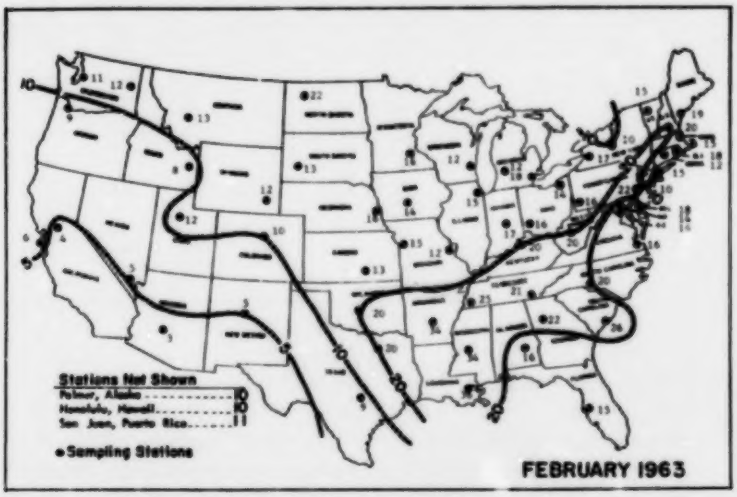
Iodine-131 monthly averages were lower in February 1963 than they were for several previous months. Forty stations were found to have levels of less than 10 μμc/liter for the month (table 2) while only 22 stations had values this low in January. The highest February iodine-131 average, observed at two of the stations, was 30 μμc/liter.

Monthly average cesium-137 concentrations in milk ranged from 25 to 135 μμc/liter during February 1963. The range of values seen at the greatest number of stations (26 stations) was 60 to 75 μμc/liter (table 3). Barium-140 averages ranged



20
50
100
200
Stations Not Shown
Palmer, Alaska 5
Honolulu, Hawaii 35
San Juan, Puerto Rico 155
● Sampling Stations
FEBRUARY 1963

FIGURE 1.—STRONTIUM-89 CONCENTRATIONS IN PASTEURIZED MILK



10
20
Stations Not Shown
Palmer, Alaska 10
Honolulu, Hawaii 10
San Juan, Puerto Rico 11
● Sampling Stations
FEBRUARY 1963

FIGURE 2.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

TABLE 2.—RADIOACTIVITY IN PASTEURIZED MILK, FEBRUARY 1963

[Average radioactivity concentrations in $\mu\mu c$/liter]

Sampling locations		Calcium (g/liter)		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
		Fourth quarter 1962	Avg. for month	Fourth quarter 1962	Avg. for month	Fourth quarter 1962	Avg. for month	Fourth quarter 1962	Avg. for month	Fourth quarter 1962	Avg. for month	Fourth quarter 1962	Avg. for month
Ala:	Montgomery	1.26	1.27	40	80	15	16	40	<10	35	45	20	<10
Alaska:	Palmer	1.33	1.20	80	15	13	10	110	<10	60	60	30	20
Ariz:	Phoenix	1.32	1.21	25	20	5	3	20	<10	20	25	<10	10
Ark:	Little Rock	1.26	1.25	120	110	29	34	110	20	70	90	30	20
Calif:	Sacramento	1.32	1.21	20	10	4	4	20	<10	20	30	10	30
	San Francisco	1.34	1.23	20	50	4	6	20	<10	20	35	<10	10
Colo:	Denver	1.34	1.28	20	10	11	10	20	<10	55	70	<10	10
Conn:	Hartford	1.13	1.08	40	5	11	12	40	<10	65	65	10	10
Del:	Wilmington	1.11	1.08	50	<5	15	18	80	10	70	70	20	<10
D.C:	Washington	1.20	1.23	40	<5	18	16	60	<10	55	60	20	<10
Fla:	Tampa	1.25	1.27	30	50	10	15	50	20	125	135	10	<10
Ga:	Atlanta	1.24	1.25	55	110	17	22	60	10	55	90	20	20
Hawaii:	Honolulu	1.26	1.16	20	35	6	10	20	20	40	60	<10	20
Idaho:	Idaho Falls	1.31	1.32	25	10	13	8	40	<10	75	80	10	10
Ill:	Chicago	1.12	1.12	45	<5	12	15	70	<10	65	70	10	<10
Ind:	Indianapolis	1.17	1.11	50	10	13	17	80	<10	55	60	10	<10
Iowa:	Des Moines	1.36	1.22	75	10	14	14	110	<10	50	75	20	20
Kans:	Wichita	1.34	1.22	55	15	13	13	70	<10	40	55	20	20
Ky:	Louisville	1.23	1.23	95	25	23	20	80	<10	45	55	40	<10
La:	New Orleans	1.28	1.28	70	270	24	36	70	30	60	130	20	40
Maine:	Portland	1.15	1.14	50	<5	17	19	50	<10	110	105	20	<10
Md:	Baltimore	1.22	1.24	40	<5	17	14	60	<10	60	60	20	<10
Mass:	Boston	1.13	1.09	60	5	19	15	50	<10	110	90	20	<10
Mich:	Detroit	1.13	1.14	50	<5	15	18	70	<10	75	80	20	<10
	Grand Rapids	1.18	1.11	35	5	12	12	50	10	65	80	10	<10
Minn:	Minneapolis	1.32	1.20	70	10	23	16	70	<10	95	125	30	20
Miss:	Jackson	1.30	1.33	90	210	19	34	70	20	45	80	30	30
Mo:	Kansas City	1.33	1.21	100	20	17	15	120	<10	45	60	30	20
	St. Louis	1.35	1.24	55	10	14	12	60	<10	45	65	20	30
Mont:	Helena	1.35	1.20	45	15	16	13	80	10	85	105	30	20
Nebr:	Omaha	1.37	1.24	60	15	15	16	90	<10	55	80	20	20
Nev:	Las Vegas	1.26	1.23	25	20	6	5	10	<10	40	50	<10	20
N.H:	Manchester	1.16	1.13	50	<5	18	20	40	20	115	105	10	10
N.J:	Trenton	1.12	1.12	45	5	13	10	60	<10	65	60	20	<10
N. Mex:	Albuquerque	1.33	1.22	20	10	5	5	30	<10	25	30	20	20
N.Y:	Buffalo	1.10	1.10	40	<5	13	17	40	<10	80	80	10	<10
	New York	1.13	1.09	55	<5	17	15	80	<10	75	65	20	<10
	Syracuse	1.14	1.08	45	5	14	10	50	<10	65	65	10	<10
N.C:	Charlotte	1.27	1.30	50	25	19	20	20	<10	50	60	20	<10
N. Dak:	Minot	1.34	1.16	60	10	27	22	60	<10	75	85	20	20
Ohio:	Cincinnati	1.16	1.08	60	10	17	16	90	10	45	60	10	<10
	Cleveland	1.16	1.10	50	<5	14	14	70	<10	60	60	<10	<10
Okla:	Oklahoma City	1.21	1.24	65	50	17	20	100	10	40	55	20	<10
Ore:	Portland	1.40	1.22	150	35	18	9	60	<10	80	75	40	20
Pa:	Philadelphia	1.13	1.10	45	<5	14	22	80	<10	60	65	10	<10
	Pittsburgh	1.14	1.07	55	10	19	16	110	10	80	80	20	<10
P.R:	San Juan	1.17	1.19	75	155	10	11	30	30	45	75	10	20
R.I:	Providence	1.11	1.09	45	<5	16	18	60	10	85	70	20	<10
S.C:	Charleston	1.26	1.29	50	140	20	26	40	20	60	85	20	20
S. Dak:	Rapid City	1.17	0.92	50	20	15	13	70	10	70	80	20	10
Tenn:	Chattanooga	1.28	1.31	95	45	20	21	60	<10	50	65	30	<10
	Memphis	1.25	1.28	85	80	20	25	80	<10	40	50	30	10
Tex:	Austin	1.23	1.23	35	35	8	9	90	<10	30	30	20	<10
	Dallas	1.23	1.26	90	85	16	20	150	20	45	60	30	20
Utah:	Salt Lake City	1.35	1.26	30	15	11	12	40	10	75	110	30	20
Vt:	Burlington	1.11	1.08	55	5	13	15	60	<10	85	85	20	<10
Va:	Norfolk	1.23	1.28	45	40	20	16	50	<10	60	65	20	<10
Wash:	Seattle	1.36	1.24	100	25	21	11	60	<10	85	85	40	20
	Spokane	1.40	1.36	35	10	15	12	30	10	80	95	10	20
W. Va:	Charleston	1.22	1.24	60	10	21	20	40	10	55	50	20	<10
Wis:	Milwaukee	1.18	1.10	45	10	11	12	90	10	70	60	20	<10
Wyo:	Laramie	1.32	1.25	45	20	12	12	20	<10	80	110	10	30
Network average		1.24	1.19	55	33	15.1	1.54	61	<10	62	72	19	13

between < 10 and 40 $\mu\mu c$/liter in February, with 29 stations reporting < 10 $\mu\mu c$/liter.

The radionuclide levels observed in milk during February may be partially explained by such factors as cattle feeding practices. The *Weekly Weather and Crop Bulletin* (*1*) showed that supplemental feeding and pasturage were about normal for this time of year in the Great Plains. In the Mississippi Valley, Gulf, and South Atlantic States, below-normal temperatures held back development of pastures so that supplemental feeding was above normal during February.

TABLE 3.—DISTRIBUTION OF SAMPLING STATIONS IN SELECTED RANGES OF RADIONUCLIDE CONCENTRATIONS IN MILK, FEBRUARY 1963

Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
Range (μμc/liter)	Number of stations	Range (μμc/liter)	Number of stations	Range (μμc/liter)	Number of stations	Range (μμc/liter)	Number of stations	Range (μμc/liter)	Number of stations
<5	12	<1- 5	4	<10	40	<5- 15	0	<10	29
5- 20	30	6-10	9	10	13	20- 35	5	10	8
25- 40	7	11-15	21	20	7	40- 55	7	20	20
45- 60	4	16-20	19	30	2	60- 75	26	30	4
65- 80	2	21-25	5			80- 95	16	40	1
85-100	1	26-30	1			100-115	5		
105-200	4	31-35	2			120-135	3		
>200	2	36-40	1						

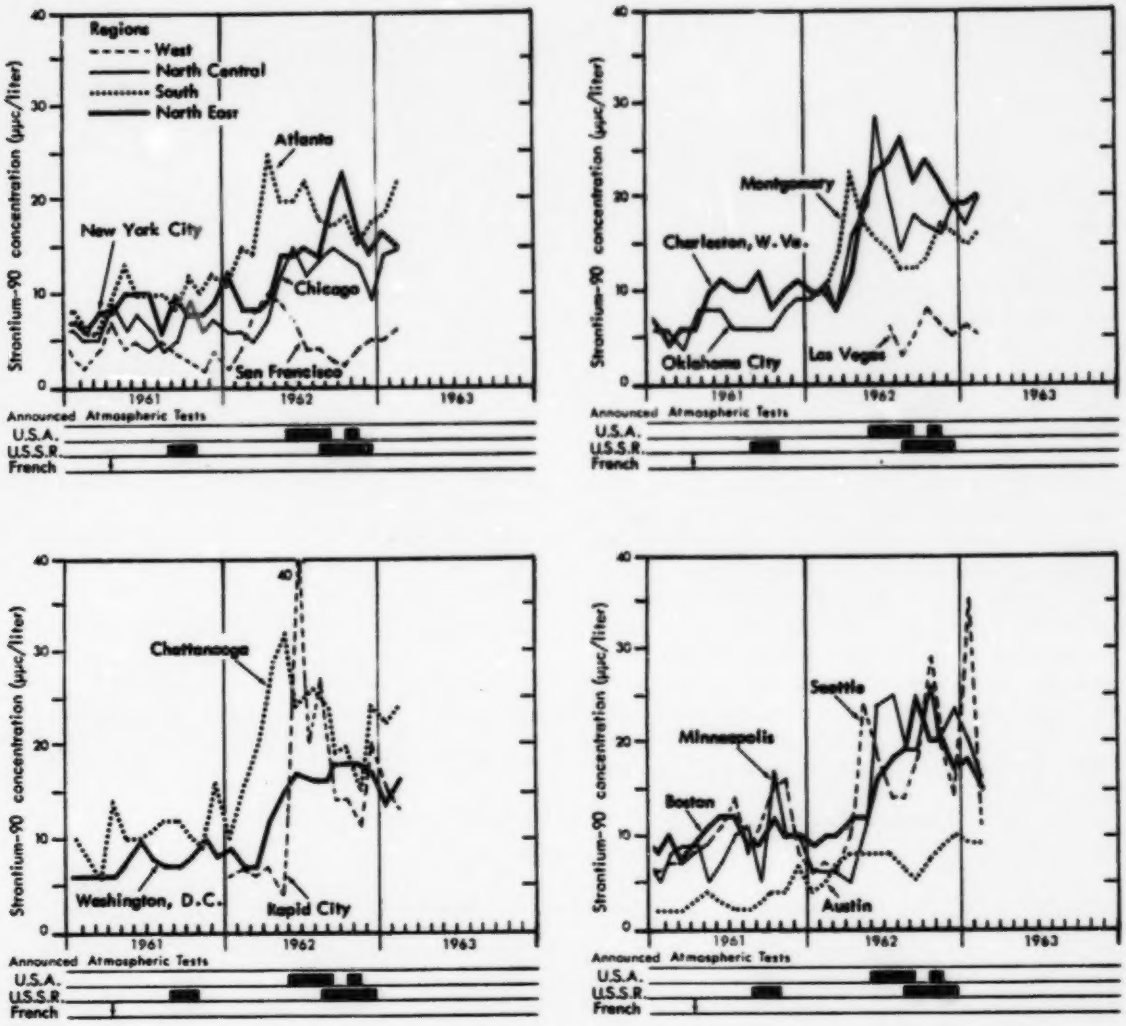


FIGURE 3.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

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Selected Monthly Strontium-90 Profiles

Continuing the practice of previous issues of *Radiological Health Data*, figure 3 presents the average monthly strontium-90 concentrations in pasteurized milk samples from 15 selected cities in the sampling program. Each individual graph shows the strontium-90 concentrations in milk from one city in each of the four U.S. Bureau of Census regions.

REFERENCE

(*1*) United States Department of Agriculture Statistical Reporting Service: *Weekly Weather and Crop Bulletin, Volumn L, Nos. 1–4*, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (February 1963), price per year $3.00, single copy price 10 cents.

INDIANA MILK NETWORK
February–March 1963

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analyses in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (see figure 4).

The milk samples are routinely analyzed for iodine-131, cesium-137, barium-lanthanum-140, strontium-89, and strontium-90. Analyses for the gamma emitters iodine-131, cesium-137, and barium-lanthanum-140 are conducted on a weekly basis except when iodine-131 results exceed 100 μμc/liter, at which time the frequency of sampling is increased. Strontium-89 and strontium-90 analyses are performed monthly on samples which are composited from weekly aliquots.

The ion exchange analytical procedure (*1*) is used for strontium-89 and strontium-90 analyses.

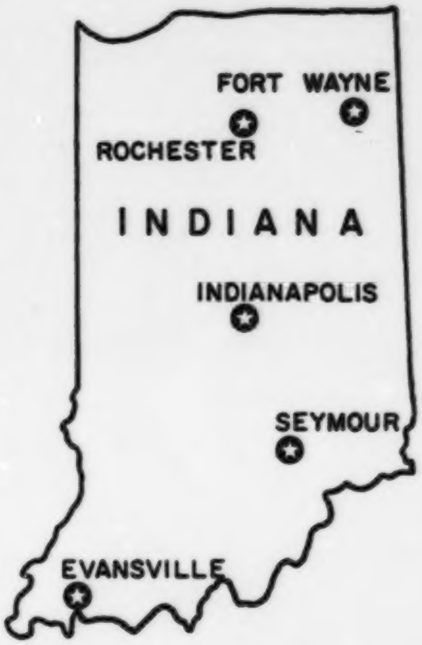

FIGURE 4.—INDIANA MILK SAMPLING LOCATIONS

A 512-channel pulse height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine-131, cesium-137, and barium-lanthanum-140.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 4. The State average is an arithmetic average of the station values.

REFERENCE

(*1*) Porter, C., D. Cahill, R. Schneider, P. Robbins, W. Perry, and B. Kahn: Determination of Strontium-90 in Milk by an Ion Exchange Method, *Analytical Chemistry 33*:1306–8 (September 1961).

TABLE 4.—RADIONUCLIDES IN INDIANA MILK, FEBRUARY–MARCH 1963

[Concentrations in μμc/liter]

Sampling location	Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-Lanthanum-140	
	February	March	February	March	February	March	February	March	February	March
Evansville	<10	80	14	18	<10	<10	40	45	<10	<10
Fort Wayne	<10	<10	18	16	<10	<10	55	55	<10	<10
Indianapolis	<10	10	16	19	<10	<10	50	50	<10	<10
Rochester	<10	<10	16	16	<10	<10	60	55	<10	<10
Seymour	<10	60	21	20	<10	<10	60	55	<10	<10
State average	<10	30	17	18	<10	<10	55	50	<10	<10

CANADIAN MILK NETWORK
January 1963

Radiation Protection Division
Department of National Health and Welfare,
Ottawa, Canada

In January 1963, the Canadian Department of National Health and Welfare substituted the radioanalysis of fresh liquid milk for the analysis of powdered milk. The Department had previously analyzed milk powders from November 1955 through December 1962, but liquid whole milk was only monitored for iodine-131 since April 1962.

With this change, it has been possible to choose milk sampling locations in the same areas as the air and precipitation stations (see figure 5). This permits the observation of a number of environmental variables which may affect the radionuclide levels in milk. In addition, it is now possible to report radionuclide concentrations in terms of the activity per liter of milk as well as per gram of calcium in milk.

A detailed discussion of the sampling and radiochemical procedures employed for milk analyses may be found in the Department's publications (*1*, *2*). Table 5 presents the results of the measurements of strontium-89, strontium-90, and iodine-131 in Canadian liquid whole milk for January 1963. These data were taken from the monthly publication, "Data from Radiation Protection Programs," of the Radiation Protection Division of the Canadian Department of National Health and Welfare.

Because of technical difficulties, no cesium-137 results for January are available. The national average iodine-131 profile (figure 6) shows that iodine-131 concentrations remained low (3 μμc/liter) during January.

It should be emphasized that the interpretation of fallout data in relation to health is a complex problem. In comparing the values of the concentration levels in a particular medium with the so-

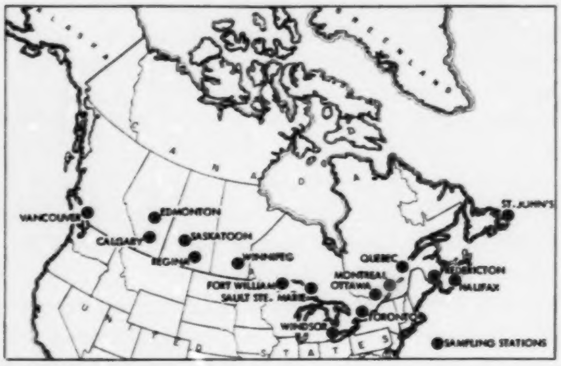

FIGURE 5.—CANADIAN MILK SAMPLING STATIONS

TABLE 5.—RADIONUCLIDES IN CANADIAN WHOLE MILK, JANUARY 1963

Station	Calcium (g/liter)	Strontium -89 (μμc/liter)	Strontium -90 (μμc/liter)	Iodine -131 (μμc/liter)
Calgary	1.19	8	20.4	[a]5 (13)
Edmonton	1.08	17	16.6	[b] —
Fort William	1.21	0	25.8	—
Fredericton	1.13	11	32.6	—
Halifax	1.14	0	26.9	3 (12)
Montreal	1.11	6	14.7	—
Ottawa	1.18	6	12.7	2 (13)
Quebec	1.09	10	26.8	4 (13)
Regina	1.08	8	14.1	—
Saint John's	1.04	12	22.7	—
Saskatoon	1.14	12	13.1	4 (13)
Sault St. Marie	1.04	23	20.1	3 (12)
Toronto	1.06	5	12.3	—
Vancouver	1.14	14	19.7	2 (13)
Windsor	1.08	0	12.9	5 (13)
Winnipeg	0.98	9	16.4	2 (13)
Average	1.10	11	19.2	3

[a] Numbers in parentheses indicate the number of samples on which the monthly averages are based.
[b] A dash indicates no sample.

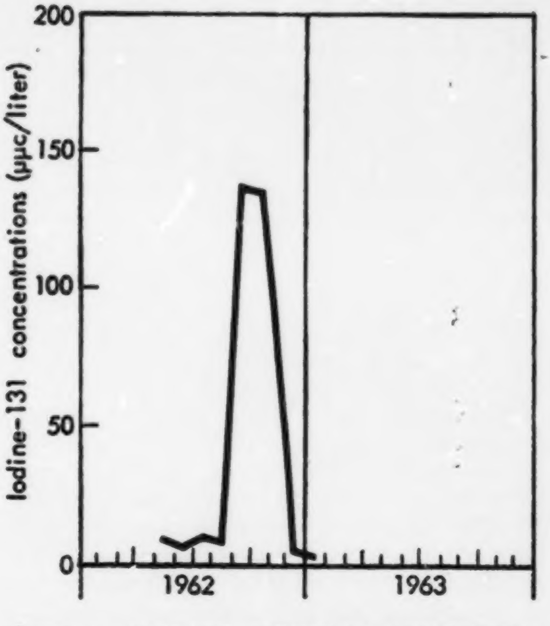

FIGURE 6.—AVERAGE IODINE-131 CONCENTRATIONS IN CANADIAN WHOLE MILK

called Maximum Permissible Concentrations (MPC's) as established by the International Commission on Radiological Protection (*3*), it is necessary to keep in mind that the MPC values refer to conditions of continuous exposure over a lifetime. Therefore, the average levels over an extended period, such as one year, afford a better basis for comparison than do individual levels at any specific time.

REFERENCES

(*1*) Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada: *The Preliminary Report of the Measurements of Radioactive Strontium in Canadian Milk Powder Samples*, (*RPD-1*), (July 1958).

(*2*) Mar, Peter G.: *Outline of Procedure for the Radiochemical Analysis of Dried Milk Powders for Strontium and Yttrium*, (*RPD-5*), Radiation Protection Division, Department of National Health and Welfare (June 1, 1960).

(*3*) Recommendations of the International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation*, Pergamon Press, New York (1959).

Twelve-Month Sum of Daily Radionuclide Content of One Liter of Pasteurized Milk

Iodine-131: April 1962-March 1963
Strontium-89 and Strontium-90: March 1962-February 1963

Division of Radiological Health, Public Health Service

The guidance of the Federal Radiation Council (FRC) is given in terms of transient rates of intake of radioactive materials in micromicrocuries per day. The action ranges proposed in FRC Report No. 2 are based on radiation doses considered acceptable for lifetime exposure from normal peacetime atomic industry operations (*1*). The Council recommends the use of a time period of one year as an appropriate interval for averaging exposures and emphasizes that the annual acceptable exposure dose is not a "danger point" which, if exceeded, requires protective measures (*1, 2, 3*).

To facilitate comparison of the concentrations of certain radionuclides in milk with the Radiation Protection Guides, tables 1 and 2 furnish estimates of the contribution of milk to the total dietary intake of iodine-131, strontium-89, and strontium-90. The tables are developed from the PHS Pasteurized Milk Network monthly averages of the radionuclides. The index values are estimated sums of the daily amounts of a radionuclide in one liter of milk for a 12-month period.

The tables show 12-month index values for each of the Network's 62 sampling locations. Due to the longer time required for strontium-89 and strontium-90 analysis, these 12-month index values are for the 12-month period beginning one month earlier than the iodine-131 values. The columns of monthly index values in each table are used to compute the net change as the 12-month index values are advanced by one month. The last column shows the latest 12-month index value. In addition, the second column in table 1 gives the March 1963 iodine-131 concentration averages.

The data in tables 1 and 2 are calculated as follows: (a) results from all samples collected in each week (Sunday through Saturday) are averaged, (b) the weekly average for all weeks ending within a given month are averaged to obtain an average value for the month, and (c) the monthly radionuclide index value is determined by multiplying the monthly average by the number of days in the month. This number will be either 28 or 35, corresponding to the number of complete calendar weeks ending in a given month. Procedures, exemplified by (a) and (b) above, tend to minimize weighting the monthly average unequally by more frequent sampling when high values are found, particularly for a short-lived radionuclide such as iodine-131. The yearly index values are obtained by the following procedure. In column (A) are the twelve-month index values for the period indicated. In columns (B) and (C) are the monthly index values for the periods indicated. The values in column (D) are obtained by adding the values in column (C) to those in column (A) and subtracting those in (B).

For a number of reasons it is desirable to use a standard quantity of milk in the development of index values for the different radionuclides. When one is concerned with strontium, 1 liter is a suitable

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TABLE 1.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF IODINE-131 IN ONE LITER OF MILK

[μμc day/liter]

Station location		Mar. 1963 iodine-131 averages (μμc/liter)	Iodine-131 index values[a]			
			Mar. 1962-Feb. 1963 (A)	Mar. 1962 (B)	Feb. 24, 1963-Mar. 30, 1963 (C)	Apr. 1962-Mar. 1963 (D)
Ala:	Montgomery	<10	6,590	180	180	6,590
Alaska:	Palmer	<10	38,220	350	180	38,050
Ariz:	Phoenix	<10	4,270	350	180	4,100
Ark:	Little Rock	10	14,670	180	350	14,840
Calif:	Sacramento	<10	5,050	180	180	5,050
	San Francisco	<10	4,940	350	180	4,770
Colo:	Denver	20	5,720	180	700	6,240
Conn:	Hartford	<10	7,670	180	180	7,670
Del:	Wilmington	<10	11,870	180	180	11,870
D.C:	Washington	<10	8,440	180	180	8,440
Fla:	Tampa	<10	6,660	180	180	6,660
Ga:	Atlanta	<10	9,040	180	180	9,040
Hawaii:	Honolulu	<10	5,250	700	180	4,730
Idaho:	Idaho Falls	<10	9,240	350	180	9,070
Ill:	Chicago	<10	13,690	180	180	13,690
Ind:	Indianapolis	<10	12,010	180	180	12,010
Iowa:	Des Moines	<10	21,840	350	180	21,670
Kans:	Wichita	<10	21,740	180	180	21,740
Ky:	Louisville	<10	10,540	180	180	10,540
La:	New Orleans	10	9,600	180	350	9,770
Maine:	Portland	<10	8,160	180	180	8,160
Md:	Baltimore	<10	8,690	180	180	8,690
Mass:	Boston	<10	7,950	180	180	7,950
Mich:	Detroit	<10	12,820	180	180	12,820
	Grand Rapids	10	9,560	180	350	9,730
Minn:	Minneapolis	<10	16,170	700	180	15,650
Miss:	Jackson	10	9,530	180	350	9,700
Mo:	Kansas City	<10	30,240	350	180	30,070
	St. Louis	<10	12,530	350	180	12,360
Mont:	Helena	<10	14,630	700	180	14,110
Nebr:	Omaha	<10	19,390	350	180	19,220
Nev:	Las Vegas[b]	10	4,240	[c]—	350	4,590
N.H:	Manchester	<10	7,710	180	180	7,710
N.J:	Trenton	<10	7,990	180	180	7,990
N. Mex:	Albuquerque	<10	7,040	700	180	6,520
N.Y:	Buffalo	<10	8,720	180	180	8,720
	New York	<10	11,660	180	180	11,660
	Syracuse	10	9,980	180	350	10,150
N.C:	Charlotte	<10	3,370	180	180	3,370
N.Dak:	Minot	10	14,910	350	350	14,910
Ohio:	Cincinnati	<10	14,600	180	180	14,600
	Cleveland	<10	11,100	180	180	11,100
Okla:	Oklahoma City	<10	18,380	180	180	18,380
Ore:	Portland	<10	9,770	180	180	9,770
Pa:	Philadelphia	<10	10,820	180	180	10,820
	Pittsburgh	<10	14,810	180	180	14,810
P.R:	San Juan[d]	10	5,960	180	350	6,130
R.I:	Providence	<10	8,580	180	180	8,580
S.C:	Charleston	10	7,010	180	350	7,180
S. Dak:	Rapid City	<10	14,670	700	180	14,150
Tenn:	Chattanooga	<10	7,850	180	180	7,850
	Memphis	<10	10,050	180	180	10,050
Tex:	Austin	<10	11,040	180	180	11,040
	Dallas	<10	18,840	180	180	18,840
Utah:	Salt Lake City	10	31,920	350	350	31,920
Vt:	Burlington	<10	8,380	180	180	8,380
Va:	Norfolk	<10	6,410	180	180	6,410
Wash:	Seattle	<10	9,940	350	180	9,770
	Spokane	<10	21,910	700	180	21,390
W. Va:	Charleston	<10	6,970	180	180	6,970
Wis:	Milwaukee	<10	14,460	180	180	14,460
Wyo:	Laramie	<10	19,710	350	180	19,540

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[a] The data in this table are index values, not to be interpreted as consumption or total intake values. Annual iodine-131 intake per person may be calculated from an index value in this table by applying the appropriate factor representing average individual daily milk consumption for any selected group under consideration.

Example: 12-month I^{131} index × milk consumption factor = 12-month I^{131} intake
(μμc day/liter) (liter/day/person) (μμc/person)

[b] Station included in milk network in July 1962. The sums in columns A and D are therefore for 8 and 9 months, respectively.

[c] A dash indicates no analysis.

[d] No sample was received in November 1962. The sums in columns A and D are therefore for 11 months.

TABLE 2.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF STRONTIUM-89 AND STRONTIUM-90 IN ONE LITER OF MILK

Station location		Strontium-89 index values (μμc day/liter)[a]				Strontium-90 index values (μμc day/liter)[a]			
		Feb. 1962–Jan. 1963 (A)	Feb. 1962 (B)	Jan. 27, 1963–Feb. 23, 1963 (C)	Mar. 1962–Feb. 1963 (D)	Feb. 1962–Jan. 1963 (A)	Feb. 1962 (B)	Jan. 27, 1963–Feb. 23, 1963 (C)	Mar. 1962–Feb. 1963 (D)
Ala:	Montgomery	23,555	1,540	2,240	24,255	5,474	336	448	5,586
Alaska:	Palmer	19,095	140	420	19,375	3,808	168	280	3,920
Ariz:	Phoenix	6,460	420	560	6,600	1,176	84	84	1,176
Ark:	Little Rock	50,365	3,080	3,080	50,365	10,906	616	952	11,242
Calif:	Sacramento	7,055	140	280	7,195	1,393	84	112	1,421
	San Francisco	13,020	700	1,400	13,720	1,981	112	168	2,037
Colo:	Denver	10,310	280	280	10,310	3,731	112	280	3,899
Conn:	Hartford	8,070	70	140	8,140	3,927	280	336	3,983
Del:	Wilmington	13,195	70	70	13,195	4,977	308	504	5,173
D.C:	Washington	12,760	70	70	12,760	5,285	196	448	5,537
Fla:	Tampa	9,415	700	1,400	10,115	3,633	252	420	3,801
Ga:	Atlanta	30,800	4,200	3,080	29,680	6,608	420	616	6,804
Hawaii:	Honolulu	10,045	2,240	980	8,785	1,918	224	280	1,974
Idaho:	Idaho Falls	8,875	140	280	9,015	3,486	84	224	3,626
Ill:	Chicago	10,800	70	70	10,800	4,116	168	420	4,368
Ind:	Indianapolis	13,930	70	280	14,140	4,949	252	476	5,173
Iowa:	Des Moines	23,960	140	280	24,100	4,718	140	392	4,970
Kans:	Wichita	18,620	420	420	18,620	4,270	196	364	4,438
Ky:	Louisville	28,210	420	700	28,490	7,294	336	560	7,518
La:	New Orleans	58,170	10,220	7,560	55,510	11,046	868	1,008	11,186
Maine:	Portland	10,800	70	70	10,800	5,299	364	532	5,467
Md:	Baltimore	11,815	140	70	11,745	5,544	252	392	5,684
Mass:	Boston	11,360	70	140	11,430	5,992	280	420	6,132
Mich:	Detroit	9,855	70	70	9,855	4,242	168	504	4,578
	Grand Rapids	8,560	140	140	8,560	3,794	196	336	3,934
Minn:	Minneapolis	20,285	140	280	20,425	6,216	168	448	6,496
Miss:	Jackson	55,020	8,400	5,880	52,500	8,792	588	952	9,156
Mo:	Kansas City	30,940	420	560	31,080	5,404	224	420	5,600
	St. Louis	19,390	280	280	19,390	4,963	196	336	5,103
Mont:	Helena	16,590	140	420	16,870	4,487	112	364	4,739
Nebr:	Omaha	21,035	420	420	21,035	4,889	140	448	5,197
Nev:	Las Vegas[b]	5,040	[c]—	560	5,600	1,162	—	140	1,302
Nev:	Manchester	10,415	70	70	10,415	5,362	308	560	5,614
N.J:	Trenton	9,925	70	140	9,995	4,158	252	280	4,186
N. Mex:	Albuquerque	6,185	280	280	6,185	1,617	56	140	1,701
N.Y:	Buffalo	8,980	70	70	8,980	4,228	196	476	4,508
	New York	10,555	70	70	10,555	5,075	224	420	5,271
	Syracuse	9,555	70	140	9,625	4,228	224	280	4,284
N.C:	Charlotte	20,790	980	700	20,510	7,259	308	560	7,511
N. Dak:	Minot	16,655	70	280	16,865	7,294	224	616	7,686
Ohio:	Cincinnati	17,780	560	280	17,500	5,481	308	448	5,621
	Cleveland	10,730	70	70	10,730	4,438	224	392	4,606
Okla:	Oklahoma City	26,180	1,120	1,400	26,460	6,230	308	560	6,482
Ore:	Portland	30,485	420	980	31,045	5,026	196	252	5,082
Pa:	Philadelphia	10,415	70	70	10,415	4,781	252	616	5,145
	Pittsburgh	12,215	70	280	12,425	5,754	364	448	5,838
P.R:	San Juan[d]	24,745	3,080	4,340	26,005	3,395	112	308	3,591
R. I:	Providence	9,190	70	70	9,190	4,697	280	504	4,921
S.C:	Charleston	24,780	2,380	3,920	26,320	7,014	364	728	7,378
S. Dak:	Rapid City	20,215	420	560	20,355	5,740	196	364	5,908
Tenn:	Chattanooga	42,910	2,240	1,260	41,930	8,197	448	588	8,337
	Memphis	38,010	3,780	2,240	36,470	7,798	392	700	8,106
Tex:	Austin	11,655	700	980	11,935	2,702	140	252	2,814
	Dallas	30,275	1,400	2,380	31,255	5,593	336	560	5,817
Utah:	Salt Lake City	11,220	70	420	11,570	3,367	112	336	3,591
Vt:	Burlington	10,975	70	140	11,045	4,298	224	420	4,494
Va:	Norfolk	17,395	420	1,120	18,095	6,552	336	448	6,664
Wash:	Seattle	21,945	280	700	22,365	5,523	196	308	5,635
	Spokane	13,530	140	280	13,670	4,655	168	336	4,823
W. Va:	Charleston	21,070	280	280	21,070	6,853	280	560	7,133
Wis:	Milwaukee	8,455	70	280	8,665	3,136	168	336	3,304
Wyo:	Laramie	19,165	70	560	19,655	3,864	112	336	4,088

[a] The data in this table are index values, not to be interpreted as consumption or total intake values. Annual strontium-89 or strontium-90 intake per person may be calculated from an index value in this table by applying the appropriate factor representing average daily milk consumption for any selected group under consideration.

Example: 12-month index value × milk consumption factor = 12-month intake
(μμc day/liter) (liter/day/person) (μμc/person)

[b] Station included in milk network in July 1962. The sums in columns A and D are therefore for 7 and 8 months, respectively.

[c] A dash indicates no analysis.

[d] No sample was received for November 1962. The sums in columns A and D are therefore for 11 months.

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quantity, as this amount of milk supplies approximately 1 gram of calcium, the amount used by the Federal Radiation Council in deriving the intake guidance for strontium. When one is concerned with iodine-131, the critical age group is the young infant group. Available information suggests that the average milk consumption of infants in the 6–18 month group is not more than 1 liter per day. Thus, the index value based on 1 liter of milk, though not actually an average intake value, is a useful index for estimating total intake.

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SECTION IV.—WATER

Radioactivity in Raw Surface Waters

NATIONAL WATER QUALITY NETWORK
December 1962

Division of Water Supply and Pollution Control, Public Health Service

Radioactivity levels in the surface waters of the United States have been included in the surveillance of the Public Health Service's National Water Quality Network since this nationwide sampling program was initiated in 1957. Beginning with the establishment of 50 sampling points, this network has been expanded as of March 1, 1963, to 125 stations (figure 1), which are operated jointly with State, Federal and local agencies and industry. The stations are located on the major waterways used for public water supplies, propagation of fish and wildlife, and recreational, agricultural, and industrial purposes. At these stations, samples are taken weekly, monthly, or continuously, depending on the type of analysis to be performed and on the water quality. These samples

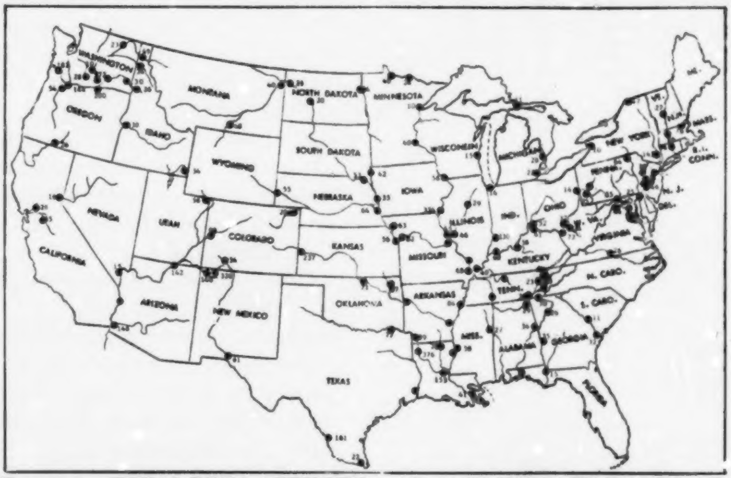
WASHINGTON
OREGON
IDAHO
MONTANA
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
WYOMING
NEBRASKA
IOWA
WISCONSIN
MICHIGAN
NEW YORK
VT.
N.H.
ME.
MASS.
R.I.
CONN.
PENNA.
N.J.
DEL.
OHIO
IND.
ILLINOIS
NEVADA
UTAH
COLORADO
KANSAS
MISSOURI
KENTUCKY
VIRGINIA
CALIFORNIA
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
TENN.
N. CARO.
S. CARO.
GEORGIA
ALABAMA
MISS.
TEXAS
FLORIDA

FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATER AT NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS, DECEMBER 1962

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS[1,2]

[Average concentrations in pc/liter]

Station	December 1962			
	Beta activity		Alpha activity	
	Dissolved	Total	Dissolved	Total
Animas River: Cedar Hill, N. Mex	18	41	4	6
Apalachicola River: Chattahoochie, Fla	32	40	0	1
Arkansas River: Coolidge, Kans	97	135	38	42
Bear River: Preston, Idaho	32	34	2	2
Bighorn River: Hardin, Mont	38	59	7	9
Sioux River: Sioux Falls, S. Dak	38	55	8	10
Chattahoochie River:				
Atlanta Ga	9	15	0	0
Columbus, Ga	9	18	0	0
Lanett, Ala	11	23	0	1
Clear Water River: Lewiston, Idaho	18	36	0	0
Clinch River: Clinton, Tenn	13	17	1	1
Colorado River:				
Loma, Colo	30	53	10	14
Page, Ariz	42	90	10	21
Parker Dam, Calif-Ariz	4	57	6	7
Columbia River:				
Northport, Wash	17	24	1	1
Wenatchee, Wash	7	10	0	0
Pasco, Wash	434	466	0	0
McNary Dam, Ore	284	320	1	1
Bonneville, Ore	183	377	1	1
Clatskanie, Ore	79	90	<1	<1
Connecticut River:				
Wilder, Vt	15	25	0	<1
Northfield, Mass	16	18	0	0
Enfield Dam, Conn	18	26	0	<1
Cuyahoga River: Cleveland, Ohio	54	67	0	<1
Delaware River:				
Martins Creek, Pa	15	19	0	0
Trenton, N. J	20	35	1	1
Philadelphia, Pa	15	33	0	1
Great Lakes:				
Duluth, Minn	4	4	0	0
Sault Ste. Marie, Mich	6	12	0	0
Milwaukee, Wis	9	10	—	—
Gary, Ind	2	3	0	0
Port Huron, Mich	8	12	0	0
Detroit, Mich	11	14	0	0
Green River: Dutch John, Utah	16	22	4	4
Illinois River:				
Peoria, Ill	19	30	0	0
Grafton, Ill	29	84	2	12
Kanawha River: Winfield Dam, W. Va	9	21	0	0
Klamath River: Keno, Ore	17	28	0	0
Little Miami River: Cincinnati, Ohio	46	57	1	1
Merrimack River: Lowell, Mass	38	102	0	0
Mississippi River:				
St. Paul, Minn	16	18	1	1
E. St. Louis, Ill	15	19	3	3
Cape Girardeau, Mo	24	45	2	2
W. Memphis, Ark	18	27	0	1
New Orleans, La	25	47	1	1
Vicksburg, Miss	27	51	1	3
Missouri River:				
Williston, N. Dak	34	76	1	1
Yankton, S. Dak	21	27	2	2
Omaha, Nebr	26	40	7	9
Kansas City, Kans	23	38	6	8
St. Louis, Mo	31	44	2	3
Missouri City, Mo	34	50	6	8
Monongahela River: Pittsburgh, Pa	11	13	0	0
North Platte River: Henry, Nebr	54	64	30	30
Ohio River:				
E. Liverpool, Ohio	11	17	0	0
Addison, Ohio	27	38	0	<1
Huntington, W. Va	13	16	0	0
Louisville, Ky	12	34	0	2
Evansville, Ind	20	29	0	0
Cairo, Ill	14	19	1	7
Pend Oreille River: Albeni Falls Dam, Idaho	15	20	<1	<1
Platte River: Plattsmouth, Nebr	37	79	7	9
Potomac River: Great Falls, Md	19	31	0	0
Rainy River: International Fls, Minn	24	28	1	1
Red River: Grand Forks, N. Dak	25	25	0	0
Red River, South:				
Denison, Tex	29	31	2	2
Index, Ark	37	72	0	4
Bossier City, La	39	239	1	6
Rio Grande River:				
El Paso, Tex	41	49	1	1
Laredo, Tex	42	62	5	5
Roanoke River: John H. Kerr Resr. & Dam, Va	18	26	0	0
Sabine River: Ruliff, Tex	38	70	1	1
Sacramento River: Greens Landing, Courtland, Calif	8	75	0	9
San Joaquin River: Vernalis, Calif	12	19	1	2
San Juan River: Shiprock, N. Mex	68	88	9	10
St. Lawrence River: Massena, N. Y	17	23	1	1
Savannah River: Port Wentworth, Ga	16	23	0	0
Shenandoah River: Berryville, Va	14	23	1	1
Ship Creek: Anchorage, Alaska	6	10	0	0
Snake River:				
Ice Harbor Dam, Wash	17	23	1	1
Wawawai, Wash	18	23	2	2
Payette, Idaho	26	36	4	4
South Platte River: Julesburg, Colo	68	96	36	38
Spokane River: Post Falls, Idaho	13	20	<1	<1
Susquehanna River: Conowingo, Md	9	16	0	0
Tennessee River:				
Chattanooga, Tenn	47	60	1	1
Bridgeport, Ala	41	41	0	0
Pickwick Landing, Tenn	36	43	0	0
Lenoir City, Tenn	14	22	0	0
Verdigris River: Nowata, Okla	49	69	<1	1
Wabash River: New Harmony, Ind	15	37	2	3
Willamette River: Portland, Ore	12	29	0	<1
Yakima River: Richland, Wash	7	10	1	1
Yellowstone River: Sidney, Mont	33	39	4	4

[1] These data are preliminary; reanalysis of some samples may be made and additional analyses, not completed at the time of the report, may become available. For final data one should consult the Network's *Annual Compilation of Data* (*7*).

[2] Dashes indicate data are not available.

are then analyzed for plankton population, organic chemicals, radioactivity, and chemical, biological, and physical quality (*1*, *2*).

Radioactivity associated with dissolved solids provides a rough measure of levels which may be found in treated water, since nearly all of the suspended matter is removed by treatment processes (*3*). It has been observed that in water the natural environmental beta activity is usually several times that of the natural environmental alpha activity. Nuclear installations may contribute additional alpha or beta activity whereas fallout contributes primarily additional beta activity. Gross alpha and beta measurements are made on both suspended and dissolved solids (strontium-90 on the total solids only) in raw surface water samples according to established procedures (*4*, *5*).

For the first two years of the network's operations, beta determinations were made on weekly samples, and alpha determinations were generally made on composites of more than one weekly sample. From January 1960 to September 1961, alpha and beta determinations were generally made once a month on weekly composited samples.

Beginning in September 1961, alpha determinations have been made on one sample each month, and beta determinations have generally been made on weekly samples. For the first operating year of each new station, sampling, and alpha and beta analyses are done weekly.

If at any time activity significantly greater than normal environmental levels has been noted, the rate of sampling and analysis has been increased to at least once every week. Since January 1959, a portion of each sample from all stations in the network has been composited into a three-month station sample for measurement of strontium-90 (*6*). Because strontium-90 analyses are done quarterly, the results will be published on this basis.

Table 1 presents the results of the alpha and beta analyses on raw surface water in the United States for December 1962. These data are preliminary; reanalysis of some samples may be made and additional analyses, not completed at the time of the report, may become available. For final data one should consult the Network's *Annual Compilation of Data* (*7*).

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the total beta activity in suspended-plus-dissolved solids in raw water collected at that station in December 1962.

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Radioactivity in Surface Waters of the United States
1957–1962

Leo Weaver, Alfred W. Hoadley, and Stanley Baker [1]

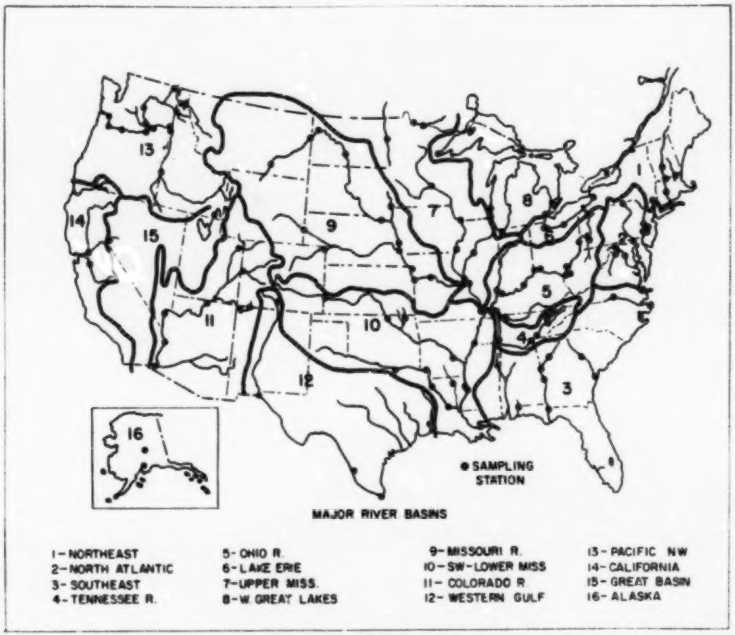
Levels of radioactivity in the surface waters of the United States have been under surveillance by the Public Health Service National Water Quality Network since its initiation in 1957. Composed at first of 50 sampling points, the network included, by March 1, 1963, 125 stations (see figure 1) operated jointly with State, Federal and local agencies, and industry. Surface waters of all major river basins of the United States are sampled and analyzed physically, chemically, biologically, and radiologically. The network can then provide data for evaluating sources of radioactivity which may affect all legitimate uses of surface water. Further, the Network provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be subjected.

The purpose of this article is to discuss Network measurements of radioactivity in surface waters, to report on levels of radioactivity in these surface waters, and to explore the meaning of certain data collected since 1957. Data assembled through the network are published in an annual compilation (*1, 2, 3, 4*).

Radioactivity Measurements

One-liter grab samples are collected weekly by personnel of the participating agencies and shipped to the Public Health Service's Network Laboratory in Cincinnati, Ohio for analysis. Determinations of radioactivity in the suspended and dissolved solids are carried out on a frequency schedule based on need.

Gross beta activity in each weekly sample was determined until essentially background levels were reached in 1960. Then, beginning in January 1960, gross beta determinations were made on monthly composites of the weekly samples received from all stations except those below known poten-


13
14
15
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8
6
1
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10
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16
● SAMPLING STATION
MAJOR RIVER BASINS
1 – NORTHEAST
2 – NORTH ATLANTIC
3 – SOUTHEAST
4 – TENNESSEE R.
5 – OHIO R.
6 – LAKE ERIE
7 – UPPER MISS.
8 – W. GREAT LAKES
9 – MISSOURI R.
10 – SW – LOWER MISS
11 – COLORADO R.
12 – WESTERN GULF
13 – PACIFIC NW
14 – CALIFORNIA
15 – GREAT BASIN
16 – ALASKA

FIGURE 1.—MAJOR RIVER BASINS OF THE UNITED STATES SHOWING NATIONAL WATER QUALITY NETWORK STATIONS

tial sources of radioactive waste production and those from all newly established network stations. (Weekly alpha and beta measurements are scheduled routinely during the first year of operation at newly established stations.) On September 1, 1961, weekly determinations of gross beta activity were again initiated to permit rapid evaluation of fallout effects from renewed weapons testing. This practice was continued until the end of October 1962, when samples for gross beta analysis were again composited monthly. Gross alpha determinations were made once monthly, except where variable or high values observed during the first year indicated the need for more frequent measurement.

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[1] Mr. Weaver is Chief, and Messers. Hoadley and Baker are staff members, Water Quality Section, Basic Data Branch, Division of Water Supply and Pollution Control, Public Health Service, Robert A. Taft Sanitary Engineering Center, Cincinnati 26, Ohio.

Normally, samples are received at the network laboratory within the week following collection. They are generally counted within two weeks after collection or within one week after compositing. The decay of activity is followed on samples that show unusually high activity during the first analysis. Also, if a recount indicates that the original analysis was questionable, values based on the recount are recorded. Results are reported for the time of counting and are not corrected by extrapolation to the time of collection.

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*5*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 microns; planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred filter membrane) in an internal proportional counter.

Since the fourth quarter of 1958, strontium-90 analyses have been made on 3-month composite samples made from weekly aliquots. Until the fourth quarter of 1961, the method used for determining strontium-90 was that described in the preceding reference. Tributylphosphate was used to extract ingrown yttrium-90 from the purified coprecipitated strontium-90. Since that time, a modification of a procedure described by Harley has been used (*6*). With this method, the yttrium-90 is coprecipitated with an yttrium carrier at a pH of 8.5; the precipitate is washed, redissolved, and reprecipitated as yttrium oxalate; and the latter is washed and counted in a low background, anticoincidence, end-window proportional counter.

Gross Beta Radioactivity

The pattern of gross beta radioactivity in the surface waters of the United States is shown in figure 2, which presents the quarterly median values of monthly station means of gross beta radioactivity of samples from the 47 stations that have been in operation since network sampling was started in 1957. This graph very clearly reflects the effects of fallout on surface waters. Activity levels ranged from 25 to 105 $\mu\mu$c/liter until the summer of 1959. At that time the levels dropped significantly, remaining for the most part below 10 $\mu\mu$c/liter from the fall of 1959 until the third quarter of 1961 when nuclear weapons testing in the atmosphere was resumed. A definite increase to over 60 $\mu\mu$c/liter in the first quarter of 1962 can be observed. The drop in the third and fourth quarters of 1962 probably can be attributed to a decrease in precipitation and runoff during this period of the year.

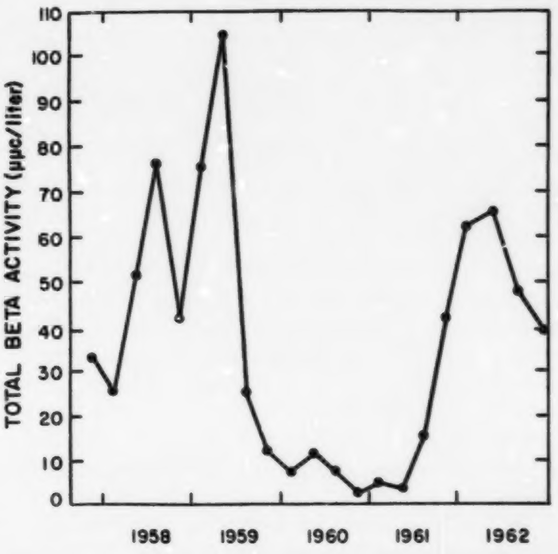

FIGURE 2.—QUARTERLY MEDIAN VALUES OF MONTHLY STATION MEANS OF GROSS BETA RADIOACTIVITY IN THE SURFACE WATERS OF THE UNITED STATES

A similar pattern can be observed in the curve representing the network mean values of quarterly composite strontium-90 analyses (figure 3). Strontium-90 levels dropped from 1.5 $\mu\mu$c/liter during the second quarter of 1959 to 0.6 $\mu\mu$c/liter during the first quarter of 1960. They remained at approximately this level until the resumption of

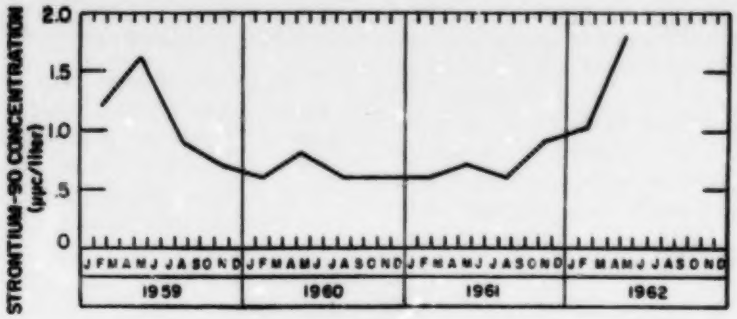

FIGURE 3.—NETWORK QUARTERLY MEAN STRONTIUM-90 IN SURFACE WATERS OF THE UNITED STATES

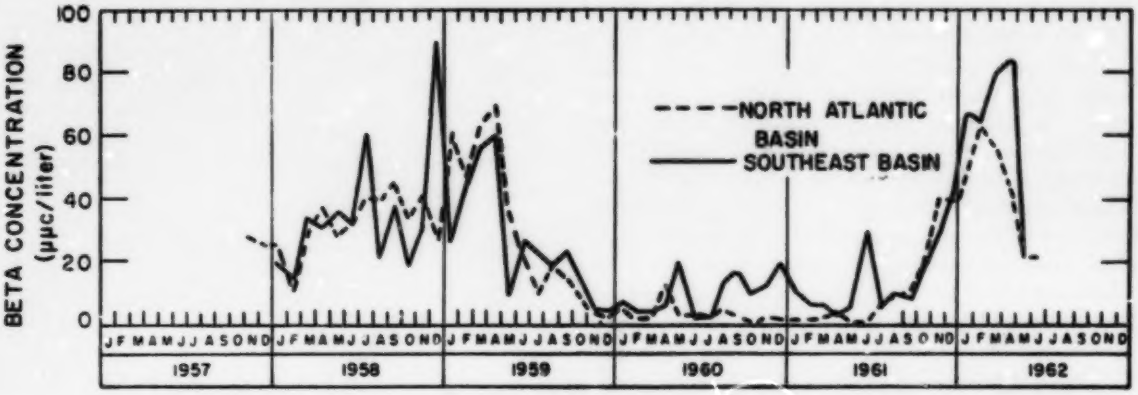

FIGURE 4.—BASIN MEANS OF GROSS BETA RADIOACTIVITY IN THE NORTH ATLANTIC AND SOUTHEAST BASINS

atmospheric nuclear weapons testing in 1961. The final quarter of 1961 reflected the beginning of an upward trend that reached 1.8 μμc/liter during the second quarter of 1962. These values for strontium-90 concentrations in river waters are low compared to the Public Health Service Drinking Water Standard of 10 μμc/liter (7). Further comparison of the value of 60 μμc/liter gross beta radioactivity to the Drinking Water Standard of 1,000 μμc/liter indicates that fallout does not contribute radioactivity approaching levels considered significant in drinking waters.

The above value of 1.8 μμc of strontium-90/liter of water is low in comparison to the Public Health Service Drinking Water Standards (7) which specify that water supplies should not exceed 10 μμc of strontium-90/liter. This low proportion of strontium-90 to the limiting value of 10 in the Standards permits comparison of the value of 60 μμc/liter of gross beta activity to the limiting value of 100 μμc/liter in the Standards.

Gross beta radioactivity profiles for six river basins are shown in figures 4–6. These curves are based on monthly means of weekly analyses or results of analyses of monthly composites. The monthly results of all stations in the respective basin are averaged to give a basin mean. Each of these curves reflects the national pattern shown in figure 2. In the North Atlantic and Southeast drainage basins, the levels of gross radioactivity (figure 4) are slightly below the national levels. Curves for the Ohio and Upper Mississippi River Basins (figure 5) are similar to those for the nation, but gross beta radioactivity levels responded more quickly to renewed weapons testing and the peaks are higher. The pattern for the Missouri and Lower Mississippi River Basins farther to the west (figure 6) also reflects fallout activity, but the peaks are higher than for the Ohio and Upper Mississippi River Basins. Meteorological and, to some degree, geological conditions undoubtedly influence the fallout pattern as reflected by radioactivity in the surface waters of the United States.

It can be seen in figure 7 that the pattern typical

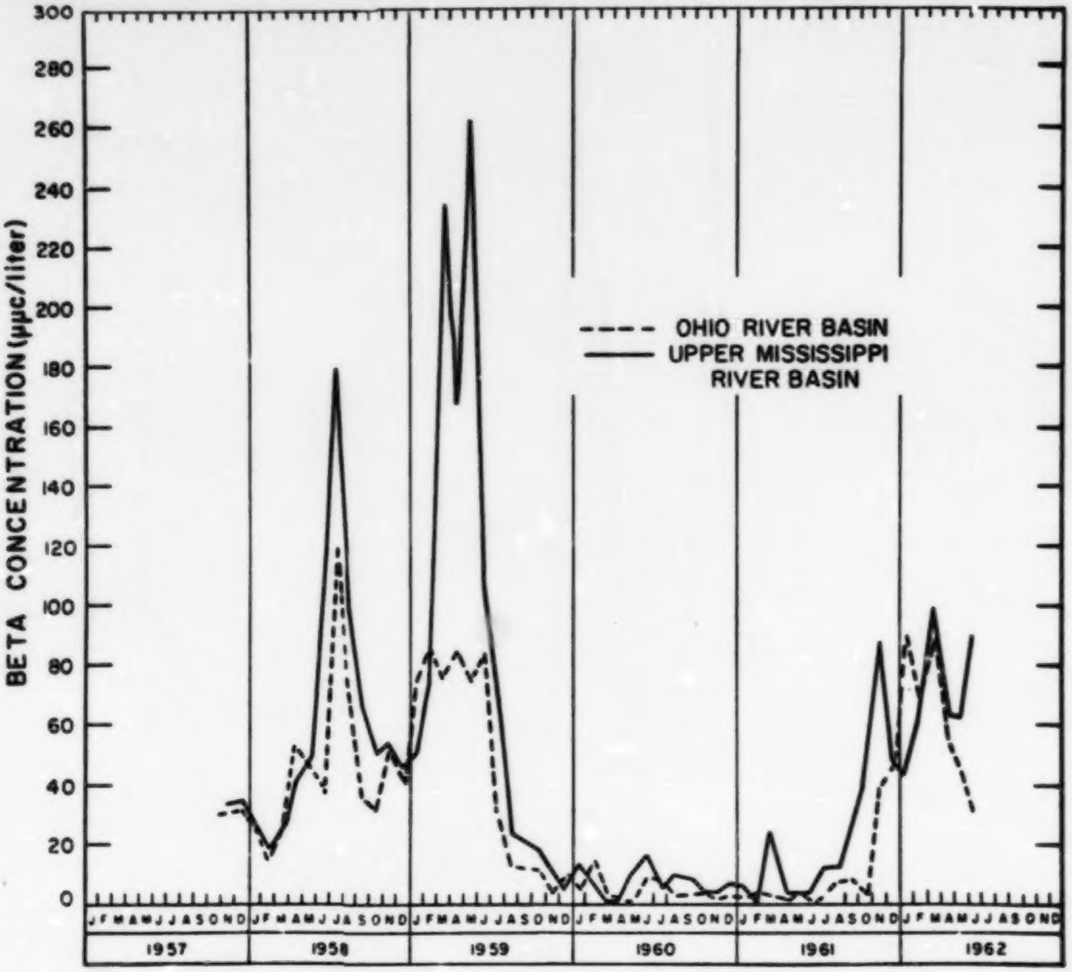

FIGURE 5.—BASIN MEANS OF GROSS BETA RADIOACTIVITY IN THE OHIO RIVER AND UPPER MISSISSIPPI RIVER BASINS

for the nation does not occur in the Columbia and Tennessee River Basins. In these basins, the effects of fallout are not evident. The higher levels of activity reflect effects of operations at the Hanford Works and Oak Ridge National Laboratory respectively, and the cyclic nature of the curves is a function of stream flow.

The relation of stream flow to radioactivity in the Columbia River at Pasco, Washington, is explored in figures 8 and 9. Figure 8 is plotted from monthly means of weekly samples for both stream flow and gross beta radioactivity taken on the same day and it is apparent that lower radioactivity levels are associated with the dilution provided by high flow. The quantitative aspect of this relationship is indicated in figure 9. Here stream flow plotted against the gross beta radioactivity concentration on a log-log scale strongly suggests a straight line relationship, as would be expected. The slope of this line is about −0.68. The deviation of the slope from negative unity would seem to indicate other effects of a systematic nature. The inverse relationship of radioactivity to stream flow in the Columbia River at Pasco is not a general one, however.

Quarterly mean stream flow and gross beta radioactivity for the Rio Grande at Laredo, Texas, are plotted in figure 10. Here the high radioactivity levels are associated with high stream flows. This relationship suggests that radioactive materials

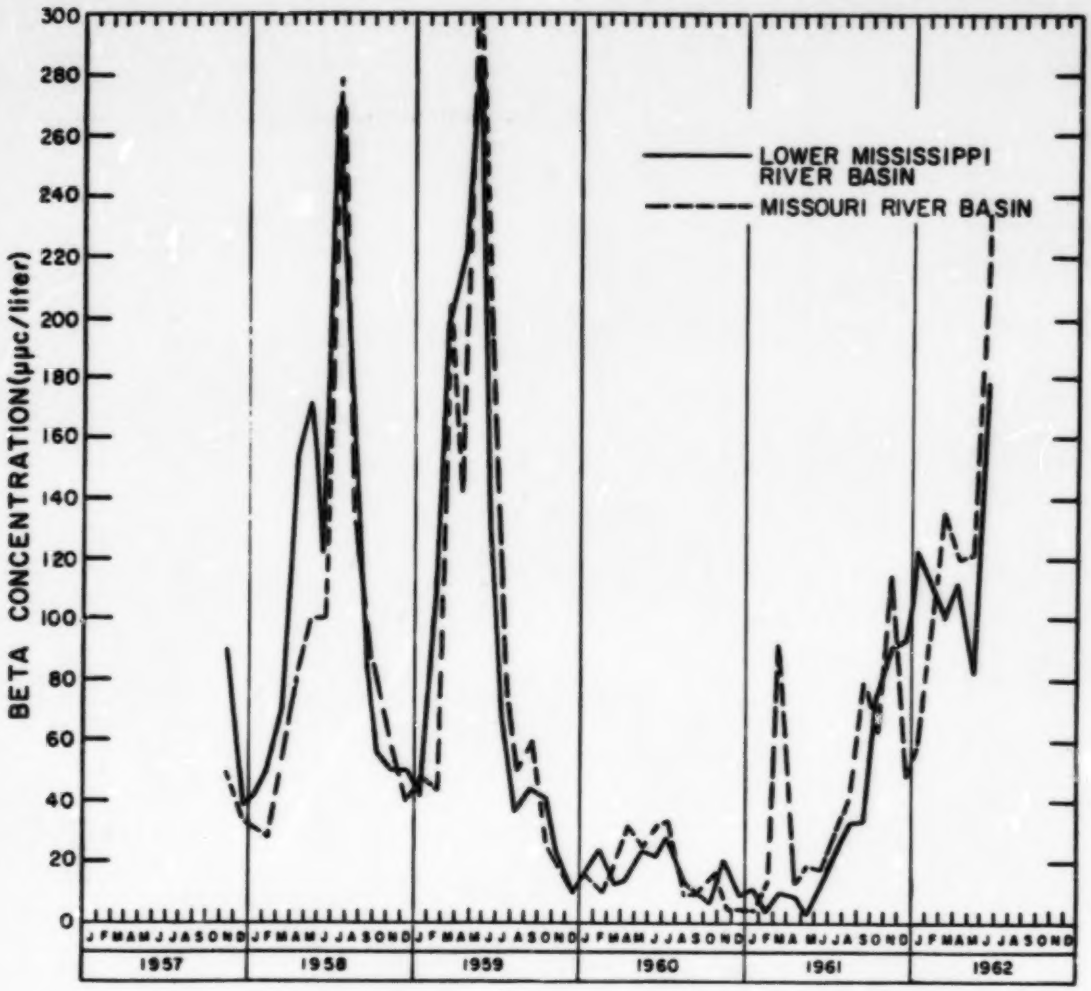

FIGURE 6.—BASIN MEANS OF GROSS BETA RADIOACTIVITY IN THE MISSOURI RIVER AND LOWER MISSISSIPPI RIVER BASINS

that occur naturally or originate from fallout are washed into the stream by runoff from the land during periods of rain. The many variables that might be expected to influence such a system make direct correlation of stream flow with radioactivity levels difficult. However, by an examination of the slopes of flow data and radioactivity, and an appropriate test of the sizes of these slopes, it can be shown that it is 95 percent certain that a non-random, or direct, relationship exists between stream flow and gross beta radioactivity concentrations in this stream. It is interesting to note that radioactivity in the Columbia River is largely in dissolved form, whereas that associated primarily with runoff, as in the Rio Grande, is found in both the suspended and dissolved matter.

Figures 11–13 are presented to show the effects of a large impoundment on the radioactivity load in a stream. The settling effects on suspended gross beta and suspended gross alpha radioactivity in Lake Mead on the Colorado River are shown in figures 11 and 13, respectively. The levels at Page, Arizona, above Lake Mead are considerably higher than those at Boulder City, Nevada, below Lake Mead, where the levels are nearly zero. Therefore, the suspended matter has evidently settled in Lake Mead. From National Water Quality Network data, it has been estimated that the difference between the alpha radioactivity passing Page and that leaving Lake Mead at Boulder City during the 1959–60 water year was over 457 curies. Figure 12, on the other hand,

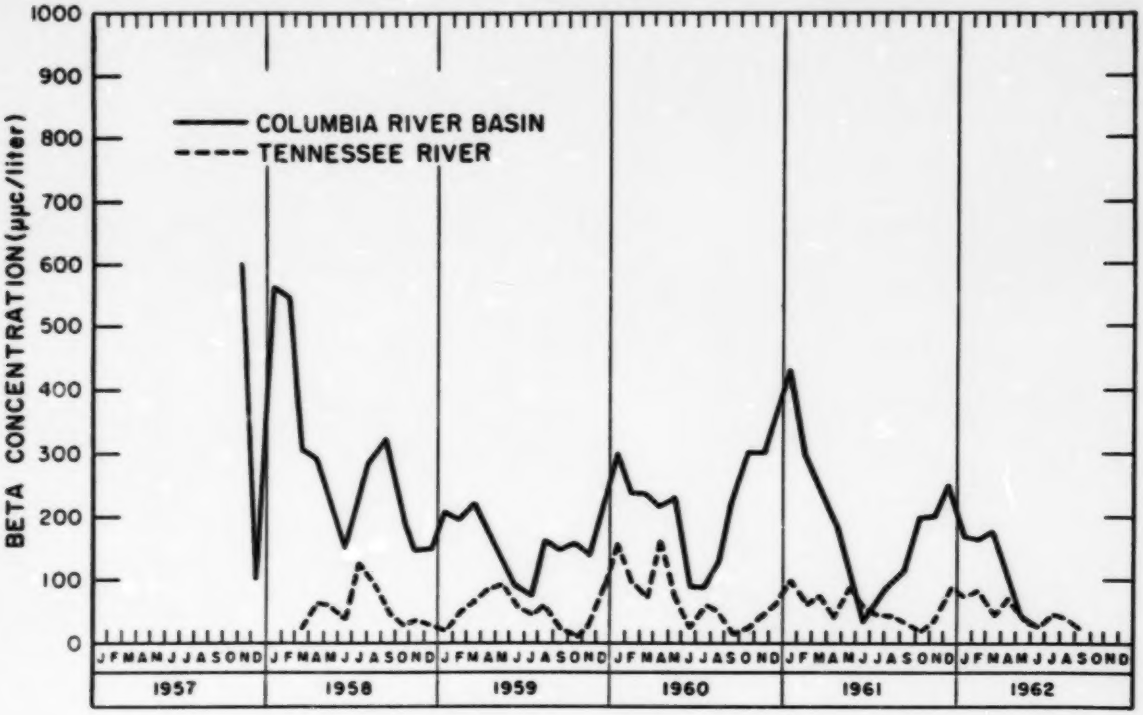

FIGURE 7.—BASIN MEANS OF GROSS BETA RADIOACTIVITY IN THE COLUMBIA RIVER BASIN AND TENNESSEE RIVER

presents data for the Page and Boulder City sampling points which show a pattern of dissolved gross beta radioactivity very similar to what would be expected from fallout.

Gross Alpha Radioactivity

Gross alpha radioactivity, since it is not an appreciable part of fallout debris, does not generally fluctuate in surface waters as does gross beta radioactivity. The waters of the United States can thus be characterized in a general way with respect to gross alpha radioactivity content. Figure 14 presents such a characterization. This map has been prepared on the basis of mean gross alpha activities at each sampling station during its period of operation. The lines delineating concentration zones were located by interpolation between values and by outlining river basins when interpolation was not deemed suitable. (Cases of high alpha activity occurred at certain stations in low activity areas and vice-versa.) In general, zones of less than 1 μμc/liter may be oberved in the East and Northwest. The period of record for Alaska is less than one year, but the data available indicate mean values of less than 1 μμc/liter. Streams arising in the Rocky Mountians show alpha activity averaging greater than 20 μμc/liter. Values of 10 to 20 μμc/liter are found in the Upper Colorado River Basin and in the Yellowstone, Missouri, and Arkansas River, values for the latter three undoubtedly resulting from dilution of the higher activity concentration flowing from the upper reaches of these streams. All other streams sampled through the network have activities averaging from 1 to 10 μμc/liter.

In view of persistent, high gross alpha activities, particularly in the Rocky Mountain areas, studies are being conducted to determine the occurrence of radium in the regions of high activity. More complete future identification is planned for the isotopes responsible for this alpha activity at Network Stations.

Relatively high alpha activities observed at the Yellowstone River sampling point appear to originate to a large extent in the Bighorn River. Samples from the Bighorn River frequently contain high activity associated with high suspended

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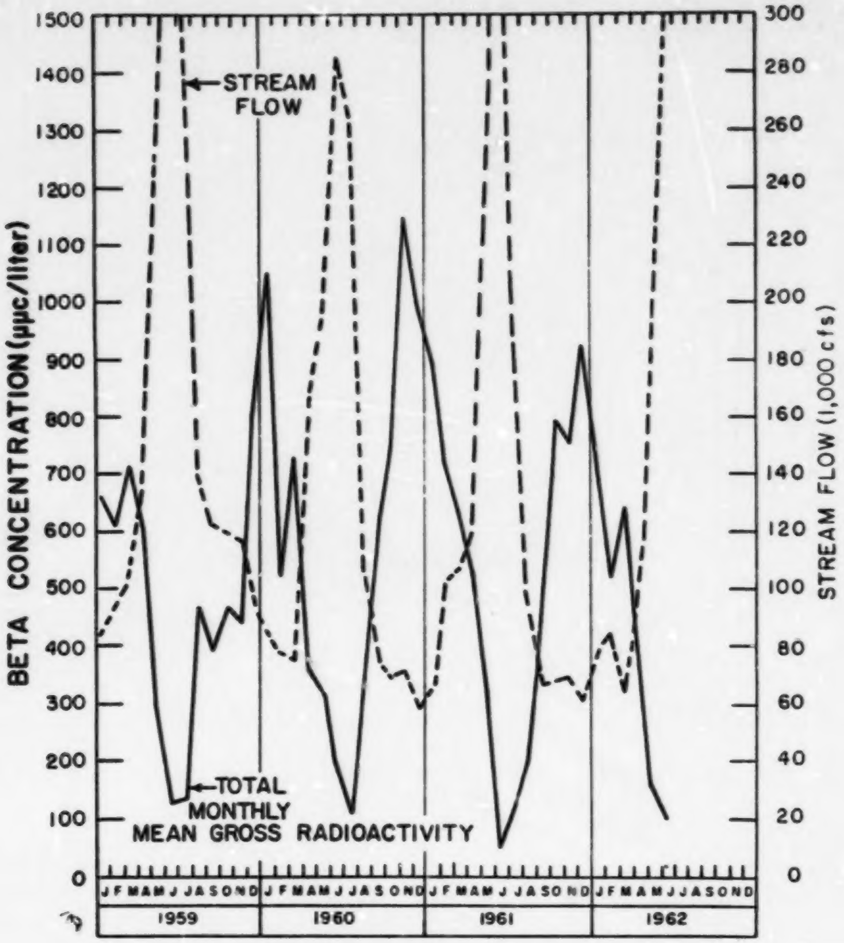

Figure 8.—GROSS BETA RADIO ACTIVITY AND STREAM FLOW IN THE COLUMBIA RIVER AT PASCO, WASHINGTON

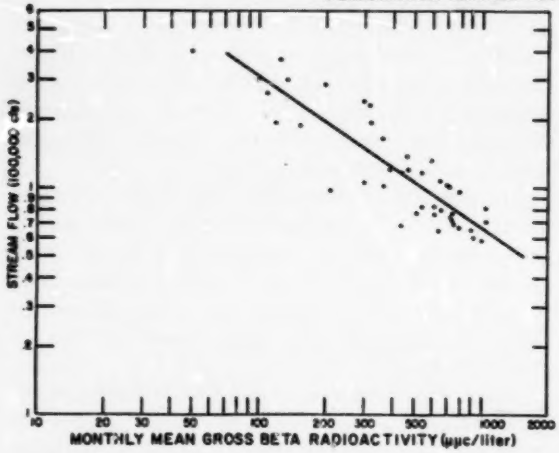

Figure 9.—STREAM FLOW VS. GROSS BETA RADIOACTIVITY IN THE COLUMBIA RIVER AT PASCO, WASHINGTON

solids. The North and South Platte and Arkansas Rivers, on the other hand, have higher activity in dissolved than in suspended matter (figure 15). In the Animas and San Juan Rivers, and particularly in the Colorado River at Page, Arizona, the alpha radioactivity is associated more with the suspended solids (figure 16). These are, at least in part, the result of uranium mining operations.

Conclusions

The data collected through the National Water Quality Network provides background information by which the behavior of radioactivity in surface waters can be better understood, and from which unusual situations can be identified and trends defined. Although weapons testing

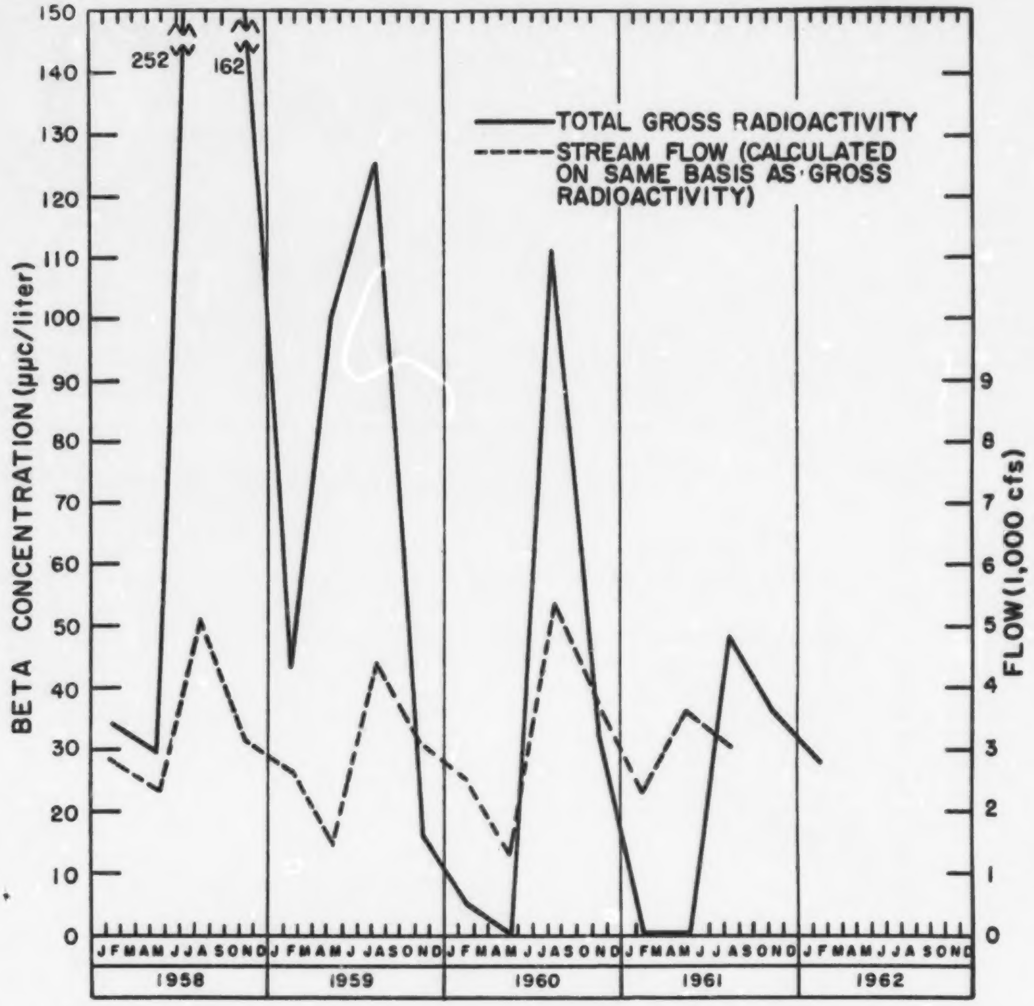

FIGURE 10.—QUARTERLY MEAN GROSS BETA RADIOACTIVITY AND STREAM FLOW IN THE RIO GRANDE AT LAREDO, TEXAS

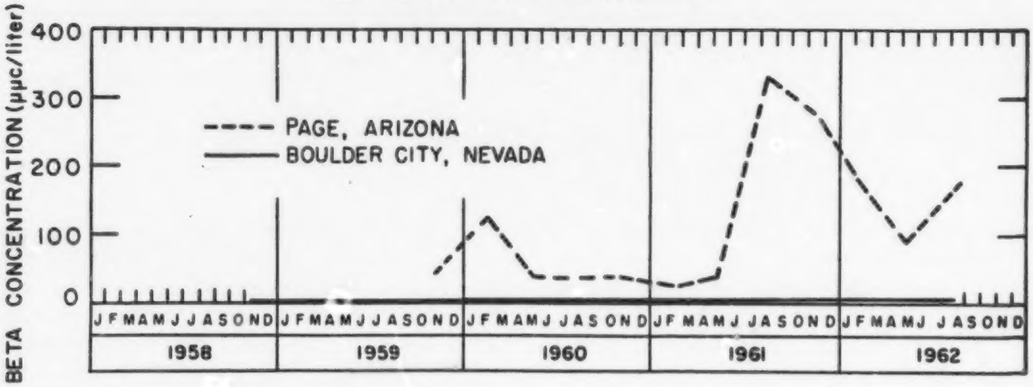

FIGURE 11.—SUSPENDED GROSS BETA RADIOACTIVITY IN THE COLORADO RIVER AT PAGE, ARIZONA, AND BOULDER CITY, NEVADA

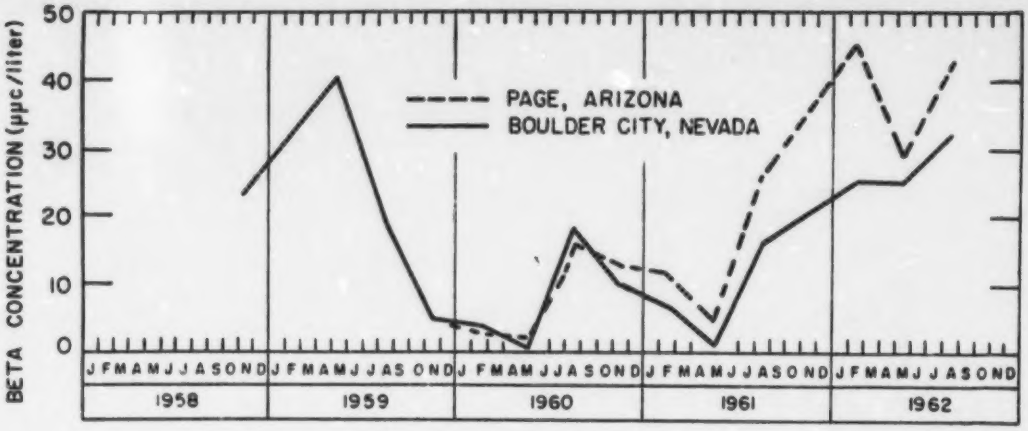

FIGURE 12.—DISSOLVED GROSS BETA RADIOACTIVITY IN THE COLORADO RIVER AT PAGE, ARIZONA, AND BOULDER CITY, NEVADA

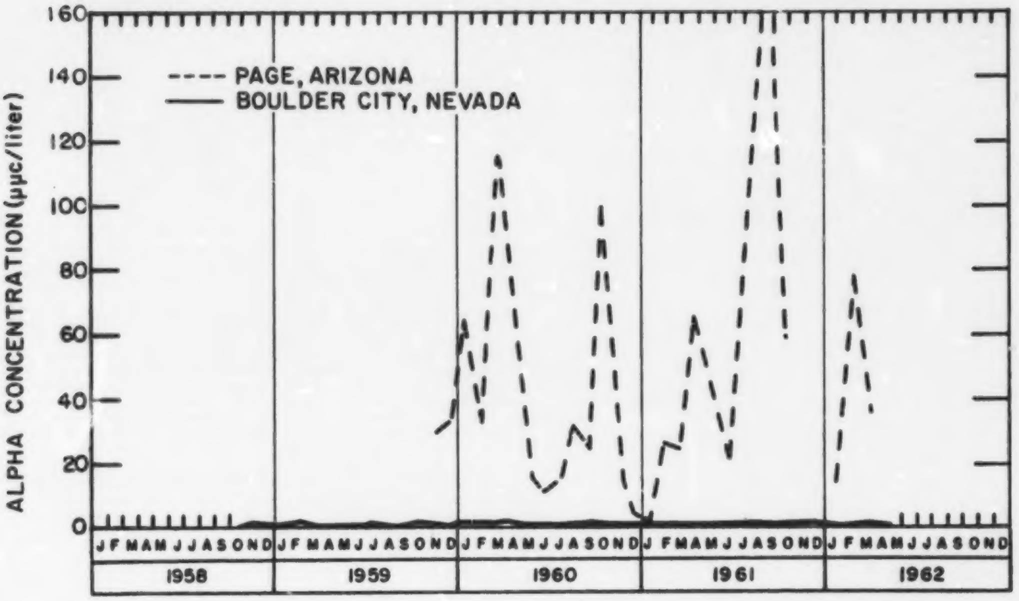

FIGURE 13.—SUSPENDED GROSS ALPHA RADIOACTIVITY IN THE COLORADO RIVER AT PAGE, ARIZONA, AND BOULDER CITY, NEVADA

recognizably affects our water, fallout has not contributed radioactivity even approaching levels considered of significance in drinking waters. The Public Health Service Drinking Water Standards (7) include recommended limits of 1,000 μμc/liter of gross beta radioactivity and 10 μμc/liter of strontium-90 in drinking water. Comparison of levels appearing in figures 2 through 6 to these limits shows that these levels were not reached during the period of October 1957 to December 1962. The understanding of fallout patterns and the behavior of radioactivity from sources other than fallout is important to the interpretation of observations made on a stream. The National Water Quality Network is a means for providing this understanding on a national basis.

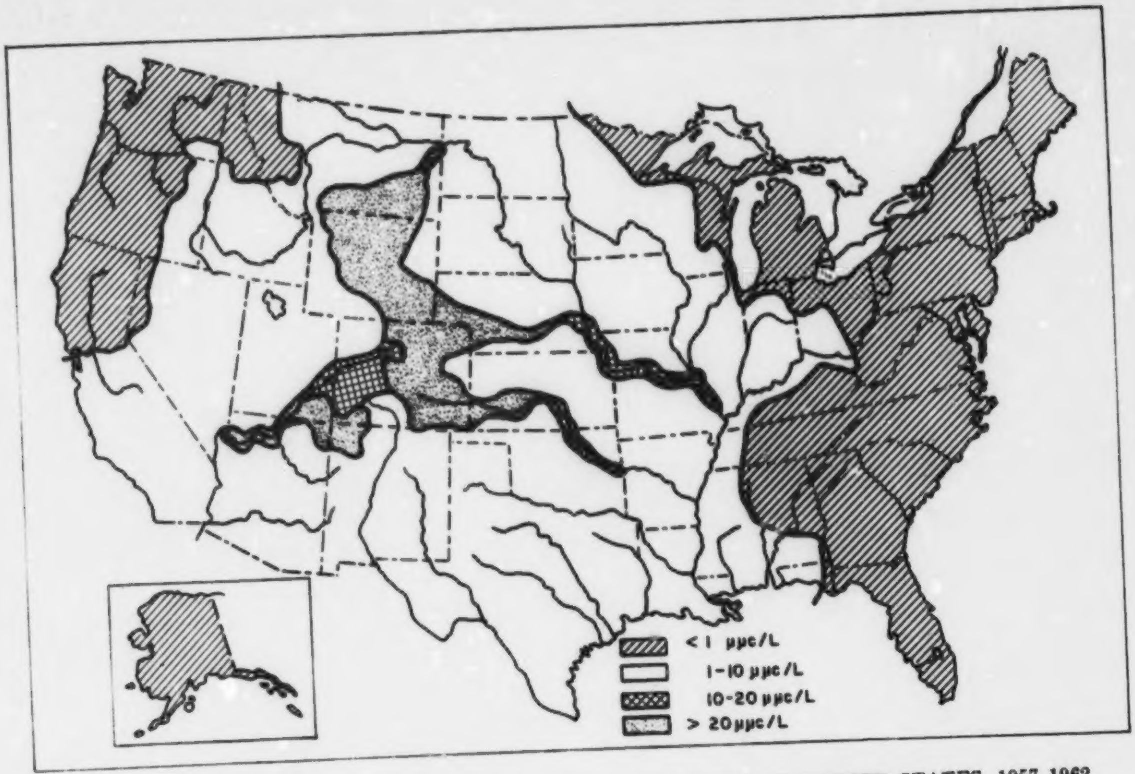
< 1 μμc/L
1-10 μμc/L
10-20 μμc/L
> 20 μμc/L

FIGURE 14.—MEAN GROSS ALPHA RADIOACTIVITY LEVELS IN THE UNITED STATES, 1957-1962

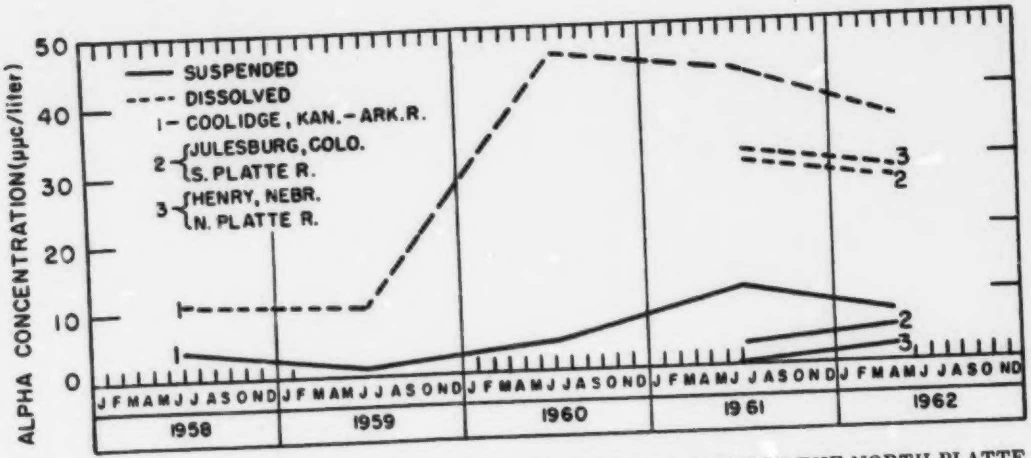

FIGURE 15.—YEARLY MEAN GROSS ALPHA RADIOACTIVITY LEVELS IN THE NORTH PLATTE, SOUTH PLATTE AND ARKANSAS RIVERS

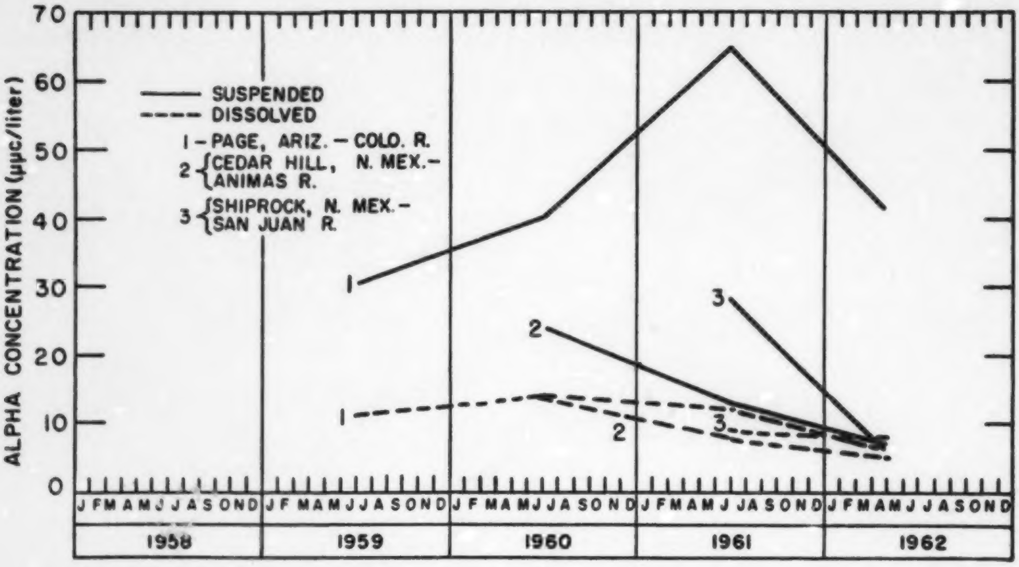

FIGURE 16.—YEARLY MEAN GROSS ALPHA RADIOACTIVITY LEVELS IN THE ANIMAS, SAN JUAN AND COLORADO RIVERS

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(2) Ibid., 1959 Edition.

(3) Ibid., 1960 Edition.

(4) Ibid., 1961 Edition.

(5) American Public Health Association, American Water Works Association and Water Pollution Control Federation: *Standard Methods for the Examination of Water and Wastewater*, 11th Edition, New York (1960).

(6) Harley, J. H.: *Radiochemical Determination of Strontium-90, Health and Safety Laboratory Manual of Standard Procedures*, Radiochemistry and Environmental Studies Division, U.S. Atomic Energy Commission, New Operations Office (August 1962 revision).

(7) Federal Register Rules and Regulations: *Title 42—Public Health Chapter 1— Public Health Service, Department of Health, Education, and Welfare; Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards, 27:* 2154–5, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (March 6, 1962).

SECTION V.—OTHER DATA

Radionuclides in the Northwestern Alaska Food Chain, 1959–1961—A Review[1]

Robert P. Chandler and Samuel Wieder [2]

Among the important findings of an extensive program of environmental studies made in conjunction with the U.S. Atomic Energy Commission's proposed Project Chariot at the mouth of Ogotoruk Creek in Northwestern Alaska are those relating to radionuclides in the indigenous food chain (*1*, *2*). These radionuclide data are included in this review, together with a summary of cesium-137 body burden determinations obtained by the AEC from more than 600 inhabitants of certain coastal and inland villages in the general area. Supplementing these data are values for the strontium-90 content of Eskimo bone and urine samples reported by Schulert (*3*).

The ecological system for this area of Alaska involves man at the top of the food pyramid with fish, marine mammals, caribou and imported foods contributing the major part of the food supply, the amount of each depending on geographic location. Lichens, a fungal-algal variety of indigenous vegetation, and sedges constitute important sources of forage for the caribou. Studies of radionuclides in this food chain have had two general objectives: (1) to furnish data from which it might be possible to predict any effects from proposed controlled nuclear detonations, and (2) to estimate exposures attributable to fission product fallout. The proposed detonations were designed to excavate a basin and channel near Cape Thompson adjacent to the mouth of the Ogotoruk Creek. The channel would lead to the Chukchi Sea off the Northwestern Alaskan coast (see figure 1). This review is concerned primarily with the second of these objectives.

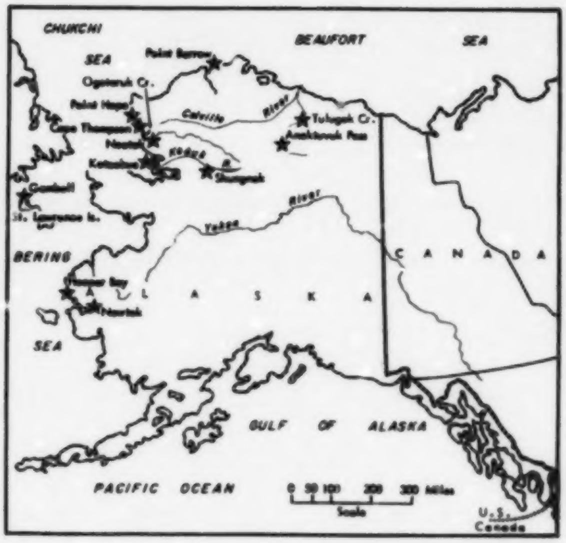
CHUKCHI SEA
BEAUFORT SEA
Point Barrow
Ogotoruk Cr.
Point Hope
Cape Thompson
Noatak
Kotzebue
Kobuk R.
Shungnak
Colville River
Tulugak Cr.
Anaktuvuk Pass
Gambell
St. Lawrence Is.
Yukon River
BERING SEA
Hooper Bay
ALASKA
CANADA
GULF OF ALASKA
PACIFIC OCEAN
0 50 100 200 300 Miles
Scale
U.S.
Canada

FIGURE 1.—INDIGENOUS FOOD CHAIN SAMPLING LOCATIONS IN NORTHWESTERN ALASKA

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[1] Abstracted from various sources (see references).

[2] Mr. Chandler is Technical Editor, and Mr. Wieder is Public Health Analyst, Radiological Health Data and Reports Staff, Division of Radiological Health, Public Health Service, U.S. Department of Health, Education, and Welfare, Washington 25, D.C.

Vegetation

Levels of radionuclides from fallout in five plant species (1960) are shown in table 1. Samples of these plants, collected in 1960 and analyzed for Mn^{54}, Zn^{65}, Sr^{90}, $Zr^{95} - Nb^{95}$, $Ru^{106} - Rh^{106}$, Cs^{137} and $Ce^{144} - Pr^{144}$, showed that the radionuclide contents of lichens, mosses and sedges were higher than those of willows and lupines.

Two of the factors which may account for differences in radionuclide concentrations in plants are age of aboveground plant parts and habitat. The time of exposure to fallout increases with increased age of the aerial parts of plants (*2*). Also, another study has shown that the accumulation of fallout debris is increased in plants growing in shallow water or saturated soils rather than in well-drained soil (*4*).

The longevity of lichens and mosses appears to be a factor accounting for their higher radionuclide concentrations as compared to annual varieties of vegetation. As the sedges *Carex* and *Eriophorum* grow in marshy places, this factor may explain in part their ability to accumulate fallout debris.

Table 2 shows the levels of gamma-emitting radionuclides in the sedge *Carex* sampled during the summers of 1959. 1960, and 1961. The 1961 samples were collected in the vicinity of Ogotoruk Creek before the resumption of atmospheric nuclear weapons testing in that year. Hence, the radionuclide levels may be attributed to fallout from weapons tests which took place prior to November 1958. The decrease of radionuclide levels in *Carex* during these years is explained as a function both of the half-lives of the radionuclides involved and of the proportions of plant tissues of different ages in the samples (*2*). The greater amounts of cesium-137 in 1961 than in 1959 samples are partly attributed to the fact that cesium-137 has a physical half-life of 30 years, and it accumulates on the top layer of the soil and is available for translocation by wind action. The physical half-life of zirconium-95 (65 days) and

TABLE 1.—FALLOUT RADIONUCLIDES IN VEGETATION AT OGOTORUK CREEK, 1960*

[Average concentrations in pc/gram dry weight]

Plant	Mn^{54}	Zn^{65}	Sr^{90}	Zr^{95}–Nb^{95}	Ru^{106}–Rh^{106}	Cs^{137}	Ce^{144}–Pr^{144}
Lichens	1.4	1.4	2.0	3.4	7.4	26	93
Moss							
Sphagnum species	1.9	1.7	3.0	0.88	17	18	134
Sedges							
Carex aquatilus	1.2	1.1	3.5	0	11	6.6	46
Eriophorum species	0.53	0.32	1.8	0.17	5.9	7.0	38
Willow							
Salix alexensis	0.31	0.17	1.2	0	3.4	3.2	22
Lupine							
Lupinus arcticus	0.40	0.15	1.1	0	3.9	2.4	14

* Abstracted from table 35 on page 144 of reference (*2*).

TABLE 2.—GAMMA-EMITTING RADIONUCLIDES IN THE SEDGE *CAREX* IN THE VICINITY OF OGOTORUK CREEK, 1959–1961*

[Concentrations in pc/gram dry weight]

Sampling date	Number of samples	Mn^{54}	Zn^{65}	Zr^{95}	Ru^{106}	Cs^{137}	Ce^{144}
August 6, 1959	9	9.1 ± 1.6†	1.0 ± 2.8	80 ± 7	16 ± 1.7	5.3 ± 1.0	240 ± 23
July 16, 1960	3	1.7 ± 0.59	1.7 ± 0.33		15 ± 0.65	8.4 ± 0.28	66 ± 23
July 31, 1961	10	0.7 ± 0.11	0.9 ± 0.15		8.1 ± 0.42	8.7 ± 0.75	28 ± 3.8

* Table 36 on page 146 of reference (*2*).

† Denotes average ± standard error.

the half-life of its radioactive daughter niobium-95 (35 days) account for the absence of these radionuclide values in the 1960 and 1961 samples reported in table 2 and for the low values reported in table 1.

Fish and Marine Mammals

Strontium-90 values in marine and fresh-water fish and in marine mammals are shown in table 3. The bulk of the samples was collected in 1959. In general, marine mammals had lower strontium-90 levels than either marine or fresh-water fish. Among the marine mammals, two samples of walrus (meat and backbone) showed the highest strontium-90 levels.

Caribou

The levels of strontium-90 and cesium-137 were generally much higher in caribou than in any of the other Alaskan dietary components sampled (*2*). These higher levels may be explained by the caribou's eating habits. Caribou browse on an assortment of vegetation, including plants that have been exposed to fallout for some time. Table 4 shows the percentage composition of caribou diets estimated from the examinations of individual rumen contents of caribou from Noatak, Colville, and Cape Thopmson in 1961. Inspection of this table indicates that lichens constitute a significant part of the diet of caribou in this area, especially in fall and winter.

Although different time periods are involved in tables 3, 5, and 6, data on strontium-90 concentrations in indigenous foods may be roughly compared. Generally, strontium-90 concentrations in caribou have shown consistently higher levels than have other indigenous foods. There was no pronounced seasonal trend for the levels of strontium-90 in caribou flesh. Whether there was any significant difference in strontium-90 levels in 1960 and early 1961 as compared to late 1961 due to the resumption of nuclear weapons testing cannot be discerned from the limited data available.

Cesium-137 concentrations in the flesh of caribou from the Colville and Cape Thompson regions during 1960–1961 are shown in table 7. A seasonal pattern of cesium-137 levels is apparent in caribou from the Colville region. The highest values occur during the winter, when plant parts that had been exposed to fallout for some time were the major source of caribou diets. The resumption of atmospheric nuclear weapons testing appeared to have contributed to the higher levels observed in November and December 1961.

Dietary Habits of Alaskan Eskimos and Indians

The food intake of residents of various geographic areas of Alaska was reported by Scott and Heller of the Arctic Health Research Center.

TABLE 3.—STRONTIUM-90 IN NATIVE ALASKAN FOODS[a]

Type of food	Location	Collection date	Strontium-90 content		
			pc/kg wet weight	pc/g ash	pc/g Ca
Marine fish					
Dried flounder and herring	Newtok	October 1959	50	0.7	2.7
Cod	Kotzebue	October 1959	163	3.0	7.9
Tom cods	Point Hope	December 1959	1.6	0.02	0.1
Needlefish	Hooper Bay	October 1959	272	3.3	7.6
Fresh-water fish					
Whitefish	Kobuk River	October 1959	70	1.0	16
Whitefish	Kobuk River	Spring 1960	[c]52	0.9	3.5
Whitefish	Kobuk River	Spring 1960	[c]635	11	33
Whitefish	Kobuk River	Spring 1960	[c]1,080	19	62
Marine mammals					
Beluga meat	Kotzebue	Fall 1959	12	0.4	142
Beluga meat	Kotzebue	October 1959	0.2	0.05	8.8
Beluga muktuk[b]	Kotzebue	October 1959		0.3	12
Seal backbone	Point Hope	Fall 1959	3.8	0.03	0.1
Walrus backbone	St. Lawrence	Spring 1959	146	0.3	0.8
Walrus meat	St. Lawrence	Spring 1959	81	4.2	360
Walrus meat	Gambell	December 1960		0.3	25
Whale meat	Point Hope	October 1959	<0.02	<0.03	<2.4
Whale rib (bowhead)	St. Lawrence	May 1959	<29	<0.05	<0.1
Land animals					
Polar bear meat	Point Hope	Fall 1959	<0.3	<0.03	<2.8

[a] Abstracted and derived from values in table 2, reference (*3*).
[b] Muktuk is the portion of whale skin found directly under the epidermis.
[c] Approximate values, since accurate wet weights were not obtained for these samples.

TABLE 4.—GROSS PERCENTAGE COMPOSITION OF INDIVIDUAL CARIBOU RUMEN CONTENTS, 1961[a]

Month	Location	Number sampled	Sedge and grass	Forbs[b]	Willow	Lichen	Moss	Miscellaneous
February	Noatak	1	[c] 5-50	5-50	0	5-50	5-50	0
March	Cape Thompson	3	5-50	5-50	5-50	5-50	<5	0
			5-50	5-50	0	5-50	<5	0
			5-50	5-50	0	5-50	<5	0
April	Cape Thompson	1	5-50	5-50	0	5-50	<5	0
May	Cape Thompson	2	5-50	5-50	0	5-50	0	0
			5-50	5-50	5-50	5-50	0	0
June	Colville	3	> 50	<5	5-50	0	0	0
			> 50	<5	0	0	0	0
			> 50	> 50	0	0	0	0
July	Colville	3	5-50	5-50	> 50	0	0	0
			5-50	5-50	> 50	5-50	0	0
			5-50	5-50	> 50	5-50	0	0
August	Colville	2	5-50	<5	> 50	<5	0	0
			<5	<5	> 50	0	0	Fungi
September	Colville	2	5-50	5-50	0	> 50	0	Fungi
			5-50	5-50	0	5-50	0	0
	Noatak	6	> 50	<5	0	> 5	0	Equisetum
			5-50	5-50	0	5-50	5-50	0
			> 50	5-50	0	0	<5	0
			> 50	5-50	0	5-50	<5	Equisetum
			> 50	5-50	0	5-50	0	Equisetum
			5-50	5-50	0	5-50	<5	Equisetum
October	Colville	6	> 50	5-50	0	0	0	Equisetum
			5-50	<5	0	> 50	<5	0
			5-50	5-50	0	5-50	<5	0
			5-50	5-50	0	> 50	<5	Equisetum
			> 50	5-50	0	5-50	<5	0
			5-50	5-50	5-50	> 50	<5	Equisetum
November	Cape Thompson	1	> 50	5-50	0	0	<5	Fungi
		4	<5	5-50	0	> 50	<5	Fungi
			5-50	5-50	0	5-50	<5	0
			5-50	5-50	0	> 50	<5	Fungi
			<5	<5	0	> 50	0	Fungi
December	Colville	4	5-50	> 50	0	> 50	0	0
			5-50	5-50	0	5-50	0	Fungi
			5-50	5-50	0	5-50	<5	0
			5-50	5-50	0	5-50	0	0

[a] Table 38, page 147, reference (*2*).
[b] Herbs, other than grasses and sedges.
[c] Value lies within the range indicated.

TABLE 5.—AVERAGE STRONTIUM-90 CONCENTRATIONS IN CARIBOU FLESH, ALASKA, 1960–1961[a]

Month	Number of caribou sampled	Strontium-90		
		pc/kg wet weight[b]	pc/kg dry weight	pc/g Ca[c]
1960				
August	5	3.7	13	37
October	3	9.7	39	97
November	3	7.6	29	76
1961				
February	2	6.0	22	60
March	7	8.8	38	88
April	2	13	56	130
May	1	2.7	10	27
June	5	4.7	20	47
July	4	6.1	24	61
August	4	6.6	24	66
September	4	7.7	30	77
October	3	7.7	31	77
November	6	9.3	68	93
December	5	9.6	38	96

[a] Table 41, page 152, reference (*2*) (modified).
[b] Frozen flesh.
[c] Assumed 100 mg Ca/kg wet flesh.

Their study (*5*) indicated that fish is a more important source of food than meat for Eskimos or Indians, and also that all Eskimos and Indians purchase part of their food in stores. Almost 60 percent of the dietary caloric intake was imported foods purchased at local stores. The dietary habits of residents of Northwestern Alaska, as characterized by the Committee on Environmental Studies for Project Chariot (*2*), showed certain special characteristics. For example, Point Hope Eskimos harvested, through hunting and fishing in 1960–1961, approximately 600,000 pounds of meat. This represented about 80 percent of the village's annual food requirements, the balance being imported. Of this total harvest, about 110,000 pounds was caribou meat, and the remainder consisted of marine and fresh-water fish and marine mammals (*2*). The above figures would indicate that about 65 percent of the total diet was composed of fish and marine mammals, and about 15 percent consisted of caribou meat.

Such information as is obtainable on the inland Eskimos indicates that a few groups are understood to eat caribou almost exclusively with some supplementation of fresh-water fish. Typical of these is a group located in the vicinity of Shungnak (*3*).

Information obtained from other studies[3] suggests that imported foods constitute a substantially larger proportion of the diets of Point Hope and Shungnak inhabitants than the foregoing figures would indicate. In contrast to the reports

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[3] Unpublished information furnished by Dr. E. M. Scott, Arctic Health Research Center, Anchorage, Alaska.

TABLE 6.—STRONTIUM-90 IN SAMPLES OF ALASKAN CARIBOU[a]

Sample	Location	Collection date	Strontium-90 content		
			pc/kg wet	pc/g ash	pc/g Ca
Antlers	Arctic Tundra	1958		44	106
Antlers	Anaktuvuk River	Oct. 1959	4,250	107	281
Antlers	Anaktuvuk River	Oct. 1959	2,920	66	170
Antlers	Tulugak Creek	Oct. 1959	2,880	64	170
Meat	Anaktuvuk Pass	Nov. 1959	7.2		160
Stomach contents	Anaktuvuk River	Nov. 1959	3,550	110	1,260
Caribou-A					
Backbone	Shungnak	Feb. 1961		54	140
Leg bone				68	175
Meat				0.6	146
Stomach contents				104	2,970
Caribou-B	Shungnak	Mar. 1961			
Backbone				61	177
Leg bone				81	180
Meat				1.5	162
Stomach contents				135	3,440

[a] Table 3, reference (*3*).

TABLE 7.—CESIUM-137 IN ALASKAN CARIBOU FLESH, 1960–1961[a]

Location	Sampling date	Number of caribou sampled	Cesium-137 average (pc/gram wet wt. ± std. error)
	1960		
Cape Thompson	August	5	0.72 ± 0.58
Colville	August	3	2.0 ± 0.89
	October	4	9.7 ± 2.6
	November	2	8.9 ± 1.6
Cape Thompson	November	1	3.7
	1961		
Colville	February	1	15
Cape Thompson	February	1	1.7
	March	7	1.0 ± 0.20
	April	2	0.75 ± 0.08
Colville	May	1	8.2
	June	5	5.6 ± 1.5
	July	3	0.64 ± 0.09
	August	4	0.90 ± 0.14
Cape Thompson	August	2	1.3 ± 0.10
Colville	September	4	4.6 ± 0.26
	October	3	6.5 ± 0.80
	November	6	19 ± 1.8
	December	5	26 ± 0.80

[a] Table 39, page 150, reference (*2*).

cited (*2*, *3*), these unpublished studies show a lower percentage contribution of fish and marine mammals to the Point Hope diet, and a lower contribution made by caribou to the Shungnak diet.

Strontium-90 in Eskimos

The strontium-90 contents of a number of native bone samples collected between November 1959 and December 1960 are shown in table 8. Both childrens' and adults' bones are included among the samples. Most of the subjects involved in this sampling lived near or along the seacoast. These data did not indicate whether or how many of the subjects were natives of Northwestern Alaska.

Schulert (*3*) observed that the average strontium-90 to calcium ratio for the adult bone samples (0.5 pc Sr^{90}/g Ca) is somewhat above the average for the rest of North America (0.3 pc Sr^{90}/g Ca for adults). There were individual samples that were relatively high (1.9, 1.4, and 1.0 pc Sr^{90}/g Ca).

Lacking bone samples from predominantly caribou-eating Eskimos, urine samples were collected from six people in the Shungnak area for purposes of estimating exposure (table 9). An

TABLE 8.—STRONTIUM-90 CONTENT OF BONES FROM NATIVE ALASKAN CHILDREN AND ADULTS[a]

Age	pc Sr^{90}/g Ca
Single bones, November 1959–December 1960	
4 months	2.4 ± 0.3
7 years	3.4 ± 0.3
16	2.4 ± 0.1
20	1.0 ± 0.2
20	0.8 ± 0.2
20	0.6 ± 0.1
24	0.4 ± 0.1
24	0.7 ± 0.2
25	0.2 ± 0.1
26	0.4 ± 0.2
26	<0.3
26	<0.1
26	1.9 ± 0.2
29	0.4 ± 0.1
30	0.5 ± 0.1
30	<0.2
32	0.2 ± 0.1
33	0.7 ± 0.1
35	1.4 ± 0.1
36	<0.2
38	0.3 ± 0.1
38	0.3 ± 0.1
39	0.8 ± 0.1
40	<0.4
42	<0.4
44	0.4 ± 0.1
46	<0.4
46	<0.2
48	0.5 ± 0.1
53	0.4 ± 0.1
54	0.7 ± 0.2
54	0.3 ± 0.2
58	0.2 ± 0.1
60	0.8 ± 0.2
60	0.4 ± 0.1
60	0.4 ± 0.1
61	0.4 ± 0.1
62	0.5 ± 0.1
Average	0.7 ± 0.1

[a] Abstracted from Table 4, reference (*3*).

average strontium-90 to calcium ratio of 25 pc Sr^{90}/g Ca was found in these samples, with individual values ranging from 19.9 to 32.1 (*3*). Previous studies by Schulert indicated that the strontium-90 level in the diet was about twice that found in the urine (*6*). This relationship, coupled with an estimated strontium-90 discrimination factor of 4 for diet to bone, produced estimates of 50 pc Sr^{90}/g Ca in the diet and 12 pc Sr^{90}/g Ca in the bone of this caribou-eating group. Schulert notes that this estimated value is more than four times the U.S. average in 1961 (*3*).

TABLE 9.—STRONTIUM-90 CONTENT IN HUMAN URINE SPECIMENS FROM ALASKA, FEBRUARY 1961[a]

Sample	pc/liter	pc Sr^{90}/g Ca
1	4.7	23.4
2	10.2	32.1
3	5.2	19.9
4	4.0	21.1
5	5.6	31.6
6	3.4	22.1
Average	5.5	25.0

[a] Table 5, reference (*3*).

Cesium-137 in Eskimos

Measurement of total body burdens of cesium-137 in people living in the Alaskan Arctic were begun in the spring of 1962, utilizing a portable whole body counter described by Palmer (*7, 8*). Counts on more than 600 people, most of them Eskimos, were obtained by July 31, 1962 (*2*). Most of the subjects resided in Kotzebue, Point Barrow, and Anaktuvuk, an inland native village in the Brooks Mountain Range. Inhabitants of various other villages between Kotzebue and Point Barrow were also measured.

The whole body measurements (table 10) showed that residents of the Anaktuvuk Pass region had the highest cesium-137 body burdens due, probably, to caribou being a major source of their food. The average body burden of fifty-three permanent residents of this region was about 420 nanocuries (nc), and the maximum body burden found was about 790 nc.

TABLE 10.—CESIUM-137 IN HUMANS, 1962[a]

Residence	Number of samples	Average body burden (nc)	Maximum body burden (nc)
Anaktuvuk	53	420	790
Kotzebue			
Eskimos	150	140	500
Students	18	45	
Non-Eskimos[b]	29	35	
Non-Eskimos[c]	25	7	
Point Barrow			
Eskimos	256	40	170
Students	47	15	
Non-Eskimos[b]	2	40	
Non-Eskimos[c]	14	6	

[a] Data from page 154, reference (*2*).
[b] Consumed indigenous foods frequently.
[c] Consumed indigenous foods infrequently (about once per month).

Residents of Kotzebue and Point Barrow exhibited lower average cesium-137 body burdens, ranging from as low as 6 nc for non-Eskimo residents to 140 nc for Kotzebue Eskimos; the maximum in the latter group was 500 nc. In the case of the Kotzebue and Point Barrow residents, the cesium-137 body burdens of Eskimos who ate indigenous food regularly can be compared with those of two groups on non-Eskimo residents—those who ate indigenous food frequently and those who did not. Also given are values for Eskimo students who are away from the region part of the year. These data suggest that cesium-137 body burdens increase as indigenous foods constitute a larger part of the diet.

For comparison, available data (*9*) indicate that body burdens of cesium-137 in the U.S., determined in the first quarter of 1962, averaged 3.9 nc (29 pc Cs^{137}/g K).

Discussion

The apparent differences in the dietary patterns of coastal and inland Eskimos of Northwest Alaska suggest that the radionuclide intake from the indigenous food chains should be considered separately for each group. It is possible to derive rough approximations of the strontium-90 composition of the diets of the Eskimos in the two regions of this area by means of data available with respect to the concentrations of this radionuclide in the various food components comprising these diets. The only information bearing on this problem and available for this review is provided by the results of the 1960–1961 hunting and fishing harvest for the Point Hope Eskimos (*2*), a coastal group. An approximate average weighted concentration of 6.6 pc/kg wet weight of indigenous foods has been derived by computing the contribution made by the specific food items, multiplied by appropriate factors according to their strontium-90 concentrations.

Similar calculations on strontium-90 in the diet of inland Eskimos, if it is assumed that the diet is mainly caribou (as is said to be the case with certain Eskimos (*3*), would yield a weighted average concentration of about 7 pc/kg, based on analyses reported for the period 1960–1961. Many inland Eskimos consume, in addition to caribou, considerable amounts of fresh-water fish. The latter have been shown to contain relatively high values of the radionuclide, as indicated in table 3, which shows a strontium-90 concentration of at least an order of magnitude greater than that for caribou (see table 5). These limited data suggest that the concentration of strontium-90 in the diet will increase as the consumption of fresh-water fish increases.

Data for cesium-137 concentrations in the diets of Northwest Alaskan Eskimos are meager. It has been found that the flesh of caribou sampled in a coastal area tended to be lower in cesium-137 concentration than flesh of caribou in an inland area (see table 7). Information of cesium-137 levels of other components of the Eskimo diets have not been available; therefore, it is not possible to evaluate the overall cesium-137 content of the respective Eskimo diets. Nevertheless, it is of interest that data on body burdens in two groups of Eskimos show relatively significant differences. As shown in table 10, the Anaktuvuk Eskimos, an inland group, exhibited substantially higher body burdens than were found in coastal Eskimos at Kotzebue and Point Barrow.

Strontium-90: Strontium-90 in the indigenous food chain in Northwestern Alaska is compared below to the Federal Radiation Council (FRC) intake guidance values. The Radiation Protection Guide (RPG) of the FRC (*10*) for *bone marrow* is 0.5 rem per year for individuals in the general population and 0.17 rem per year for an average of suitable samples of an exposed population group. The RPG for strontium-90 in mineral bone is based on the fact that the dose rate to bone from strontium-90 is three times the average dose rate to bone marrow for a given bone burden. Therefore, the RPG for *mineral bone* is 1.5 rem per year for individuals in the general population and 0.5 rem per year for the average to be applied to a suitable sample of an exposed population. The FRC stresses that the above RPG's, under normal peacetime conditions, represent an appropriate balance between benefit and risk.

Further, the FRC has established ranges of daily intake for strontium-90. Intakes between 20 and 200 pc per day (FRC Range II) would call for active surveillance and routine control and intakes up to 20 pc per day (FRC Range I) would call for routine surveillance.

Strontium-90/calcium ratios in bone have been used for determining the radiation dose from strontium-90 in a population. However, these ratios in adult bone can differ substantially from those in child bone. The difference may be attributed to two primary factors: (1) variation in the rate of calcium deposited in bone with the age of the individual and (2), whether the person was born some time prior to or after strontium-90 appeared in the environment. During the growth stage, calcium (and strontium) is deposited in bone at a much faster rate than during the adult stage in which calcium (and strontium) deposition occurs only as a result of remodeling and some mineral exchange. Since calcium (and strontium) is deposited at a much faster rate in children than in adults, children born after nuclear tests were first conducted would be expected to have higher strontium-90/calcium ratios in bone than adults would. Some indication of this relationship appears in table 8. This presupposes conditions where adults and children follow the same dietary intake patterns and live in the same geographical areas.

For the above reasons, the use of strontium-90/calcium ratios for adult bone would lead to low estimates of radiation doses from strontium-90 in children.

The higher of the two strontium-90/calcium ratios for children in table 8, 3.4 pc/g Ca, might be attributed to a continued dietary intake of about 14 pc per day assuming a discrimination factor of 4 from diet to bone (*10*), and assuming a daily intake of one gram of calcium. A daily intake of about 14 pc per day, derived from this single bone sample, represents strontium-90 intakes in FRC Range I. This calculated value reflects dietary intake of strontium-90 up to some point in time between November 1959 and December 1960.

In making the above comparison between data from bone analyses for strontium-90 and radiation protection guidance values, one must keep in mind that the relationships between intake and body burden or dose are based on constant environmental radionuclide levels throughout life.

Cesium-137: The FRC has stated (*11*) that the characteristics of cesium-137 permit direct comparison of doses received from this radionuclide with recommended whole body exposures. This same authority recommends that the average whole body dose in an exposed population group should not exceed 170 mrem per year (*12*). This value has been selected in order to insure that the

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whole body dose to the individual is less than 0.5 rem per year, the appropriate RPG.

Referring to the recommendations of the International Commission on Radiological Protection (*13*), a body burden for cesium-137 of 3,000 nc for an individual in the exposed population would correspond to a whole body dose to the individual of 0.5 rem per year. A whole body burden for cesium-137 of 1,000 nc would produce a yearly dose of 170 mrem, the whole body Radiation Protection Guide for the average population.

Thus, the maximum individual body burden in table 10, 790 nc, would represent about one-fourth of the appropriate RPG of 0.5 rem. Similarly, the highest average body burden of 420 nc in the same table represents about two-fifths of the appropriate RPG of 170 mrem for a population.

Summary

Recent findings in radionuclides in the indigenous foods chain (vegetation-diet-man) for Northwestern Alaska in 1959–1961 have been briefly reviewed. Lichens, moss and sedges, among vegetation sampled, appear to concentrate certain radionuclides to a greater extent than do other forms of vegetation in Northwestern Alaska. Certain features of the diets of various inland and coastal Eskimo groups have been presented, and some relationships have been examined between the various components of indigenous foods and their contributions of strontium-90 and cesium-137 to the native diets. It is calculated from available data that the intake of strontium-90 up to December 1960 falls within FRC Intake Guidance Range I. In the case of cesium-137, it has been found that the highest average body burden reported represents about two-fifths of the appropriate RPG of 170 mrem for a population.

Acknowledgments

Permission to reproduce portions of the tabular material from reference (*3*), presented herein in tables 3, 6, 8, and 9, had been kindly granted by Dr. A. R. Schulert, author, and Dr. P. H. Abelson, Editor of *Science*. Special acknowledgment is extended to Miss Virginia J. Croft, Editorial Assistant, for her invaluable help towards assembling this review.

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(*10*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U.S. Government Printing Office (September 1961), price 20 cents.

(*11*) Federal Radiation Council: Radiation Protection Guidance for Federal Agencies, Memorandum for the President, *Federal Register* (September 26, 1961).

(*12*) Federal Radiation Council: Radiation Protection Guidance for Federal Agencies, Memorandum for the President, *Federal Register*, pp. 4402–3 (May 18, 1960).

(*13*) International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation*, Pergamon Press, London, (1959).

Environmental Levels of Radioactivity of Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors quarterly reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Various summaries of the environmental radioactivity data for 22 AEC installations have appeared in *Radiological Health Data* since November 1960. Summaries follow for the National Reactor Testing Station and the Pinellas Peninsula Plant for the calendar year 1962.

The measured concentrations of a radionuclide in air and water may be compared with the Maximum Permissible Concentration (MPC) of that nuclide as recommended by the National Committee on Radiation Protection and Measurement (NCRP). For the environment near an AEC installation, the applicable MPC's are one-tenth of the occupational MPC values for continuous exposure given in the National Bureau of Standards "Handbook 69" (*1*). Some of the appropriate MPC's are given in table 1.

To avoid any possible misunderstandings in the use of the term "Maximum Permissible Concentrations," the Federal Radiation Council (FRC) has recommended the term "Radioactivity Concentrations Guide" (RCG) for the use of Federal agencies. Although FRC has not published a complete table of RCG values, several AEC installations, such as the National Reactor Testing Station, have adopted FRC nomenclature but use the values published by the NCRP, except for those nuclides such as iodine-131 and strontium-90, for which FRC guidance has been given. For a more detailed description of the meaning and use of the RCG, the reader is referred to FRC Reports No. 1 and No. 2 (*2, 3*).

The establishment of MPC's does not imply that each nuclide may be permitted to be present at 100 percent of its MPC concentration. If the concentration of each nuclide is expressed in terms of percent of its MPC, the sum of all the percent values should not exceed 100 percent.

In the following reports, nonspecific terms such as "total activity," "total alpha," and "gross beta" do not in themselves suggest any one MPC value. Often, when concentrations are low, a laboratory will assign an MPC value that is more restrictive than necessary. This avoids the more costly isotopic tests necessary to justify a less restrictive value. References, by line, to table 1 will be made to designate the appropriate MPC's reported by the laboratory.

REFERENCES

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(*2*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 1*, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (May 13, 1960), price 30 cents.

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TABLE 1.—SELECTED ENVIRONMENTAL VALUES PERTAINING TO AEC INSTALLATION REPORTS IN THIS SUBSECTION

Line no.	Radionuclide or mixture of radionuclides	Environmental MPC's (or RCG)	
		Water ($\mu\mu c$/liter)	Air ($\mu\mu c/m^3$)
1	If Sr^{90}, I^{129}, Pb^{210}, Po^{210}, At^{211}, Ra^{223}, Ra^{224}, Ra^{226}, Ac^{227}, Ra^{228}, Th^{230}, Pa^{231}, Th^{232}, and Th-nat are not present[a]	3,000	—
2	If Sr^{90}, Pb^{210}, Ra^{226}, Ra^{228} are not present[a]	600	—
3	If Ra^{226}, Ra^{228} are not present[a]	100	—
4	Mixture of unidentified nuclides	10	0.04
5	If α emitters and Ac^{227} are not present[a]	—	1.0
6	If α emitters and Pb^{210}, Ac^{227}, Ra^{228}, and Pu^{241} are not present[a]	—	10.0
7	If α emitters and Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{230}, Pu^{241}, and Bk^{249} are not present[a]	—	100
8	Hydrogen-3: tritium oxide (H_2^3O)	3,000,000	200,000
9	Hydrogen-3: tritium gas (H_2^3)	—	40,000,000
10	Iodine-131	[b]100	200
11	Strontium-90	[b]200	10

[a] "Not present" implies that the concentration of the nuclide is small compared with its appropriate MPC. According to recent AEC regulation (*Federal Register*, Title 10, Part 20, August 9, 1961), a group of nuclides may be considered not present if the ratio of each nuclide to its appropriate MPC is equal to or less than 1/10 and if the sum of these ratios for the group in question is equal to or less than ¼.

[b] These RCG values were adopted by the National Reactor Testing Station for its guides.

NATIONAL REACTOR TESTING STATION
Calendar Year 1962

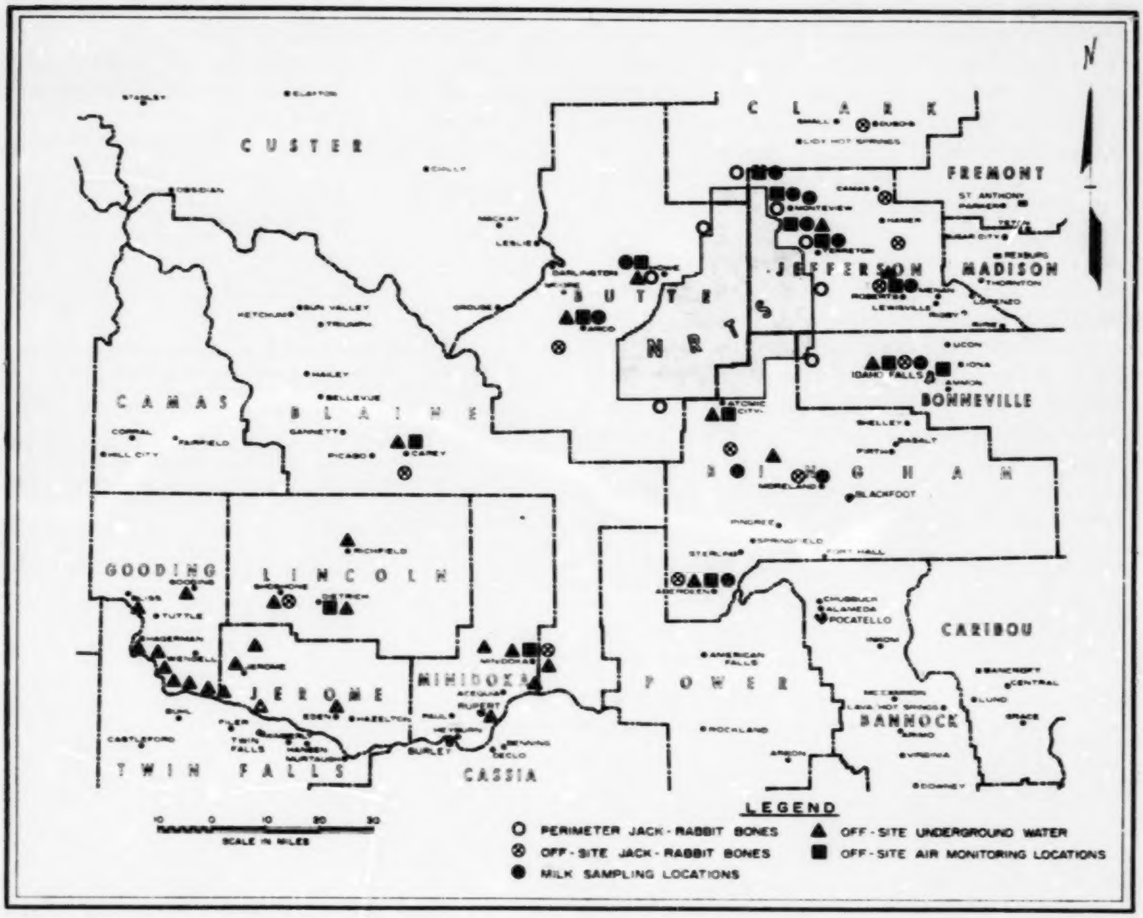
Health and Safety Division
Atomic Energy Commission
Idaho Falls, Idaho

The National Reactor Testing Stations (NRTS) is located in a very remote area which, in a large measure, permits controlled releases of radioactivity from the projects with minimum risk to the environs.

Responsibility for holding the environmental radioactivity levels at the station below the Radiation Protection Guides (RPG) recommended by the Federal Radiation Council (FRC) lies with the Atomic Energy Commission. One of the safeguards employed is a monitoring program. Descriptions of the monitoring network procedures have been presented in earlier issues. Quarterly environmental monitoring results, in addition to calendar year averages for 1962, are shown in table 2. Sampling locations at NRTS can be seen in figure 1.

Previous coverage in *Radiological Health Data:*

Period	Issue
1959 and first quarter 1960	*November 1960*
Second quarter 1960	*February 1961*
Third and fourth quarters 1960	*May 1961*
First and second quarters 1961	*January 1962*
Third and fourth quarters and calandar year 1961	*June 1962*


N
CUSTER
CLARK
FREMONT
JEFFERSON
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BUTTE
NRTS
CAMAS
BLAINE
BONNEVILLE
BINGHAM
GOODING
LINCOLN
JEROME
MINIDOKA
POWER
CARIBOU
BANNOCK
TWIN FALLS
CASSIA
IDAHO FALLS
ARCO
POCATELLO
BLACKFOOT
10 0 10 20 30
SCALE IN MILES
LEGEND
○ PERIMETER JACK-RABBIT BONES
⊗ OFF-SITE JACK-RABBIT BONES
● MILK SAMPLING LOCATIONS
▲ OFF-SITE UNDERGROUND WATER
■ OFF-SITE AIR MONITORING LOCATIONS

FIGURE 1.—ENVIRONMENTAL MONITORING STATIONS, NATIONAL REACTOR TESTING STATION

TABLE 2.—ENVIRONMENTAL MONITORING PROGRAM DATA, NRTS, 1962

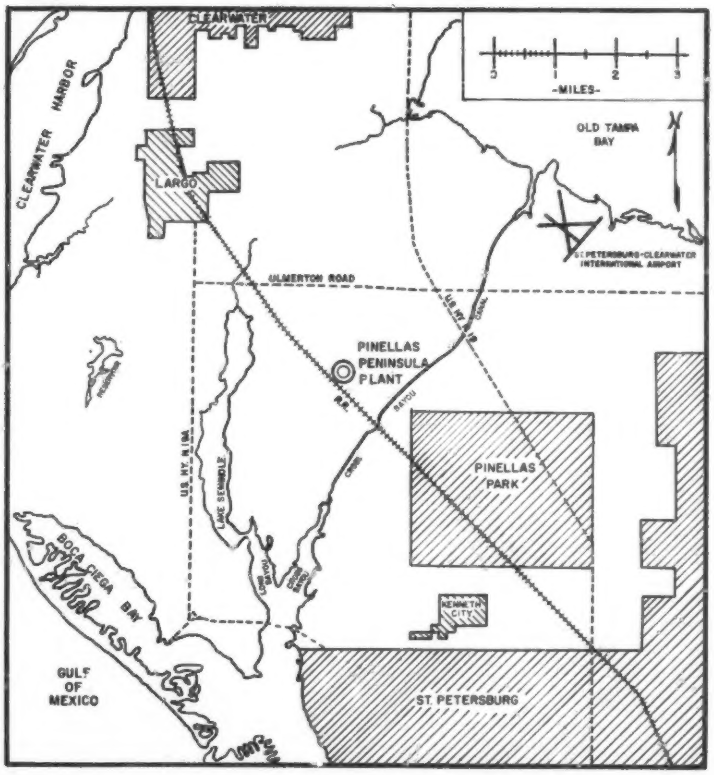
Type of sample and units	No. of stations	Approximate frequency of collections	Type of analysis	Minimum level of detection	1962 Quarterly averages				1962 Calendar year summary
					First quarter	Second quarter	Third quarter	Fourth quarter	
Off-site underground water (μμc/liter)	30	3 months	α β H^3	3 [a]6 4,300	<3.0 <150 <4,000	<3.1 <50 <4,000	<4 <30 <4,000	<3 <20 <4,000	<4 <100 <4,000
On-site production well water (μμc/liter)	21	2 weeks	α β H^3	3 [a]6 4,000	<3.1 <150 <5,900	<3.1 <130 <5,600	<3 <50 <6,000	<4 <20 <6,000	<3 <100 <6,000
Off-site air filters (μμc/m³)	14	1 week	β	(not given)	13	13	13	26	16
Off-site milk (μμc/liter)	10	1 month	I^{131}	[b]10	<50	<50	<65	<70	<60
	8	2 months	Sr^{90}	1.5	7	8	13	8	9
Off-site area monitoring badges (mrem)	14	6 weeks	γ β	10 10	<20 <20	<20 <45	[c]no data	<20 <20	<60 <85

[a] Changed from 50 to 6 in October 1962.
[b] Changed from 50 to 10 in September 1962.
[c] Film badge data not available for third quarter due to defective film.

PINELLAS PENINSULA PLANT
Calendar Year 1962

General Electric Company
St. Petersburg, Florida

Pinellas Peninsula Plant (PPP), shown in figure 2, is an electronic component production facility in the Atomic Energy Commission's Albuquerque Operations Office manufacturing complex. Environmental monitoring includes sampling of a single combined sewer effluent, milk from five local dairy farms, air, and surface water obtained at locations suggested by meteorological conditions and radioactivity discharge concentrations. Except for air samples which may contain tritium gas, the


CLEARWATER
CLEARWATER HARBOR
0
1
2
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-MILES-
OLD TAMPA BAY
N
LARGO
ST. PETERSBURG-CLEARWATER INTERNATIONAL AIRPORT
ULMERTON ROAD
U.S. HY. 19
CANAL
PINELLAS PENINSULA PLANT
R.R.
BAYOU
CROSS
U.S. HY. ALT. 19
LAKE SEMINOLE
PINELLAS PARK
BOCA CIEGA BAY
LONG BAYOU
CROSS BAYOU
KENNETH CITY
GULF OF MEXICO
ST. PETERSBURG

FIGURE 2.—LOCATION OF THE PINELLAS PENINSULA PLANT SITE

radioactive portion of the samples is essentially tritium oxide.

Air Monitoring

Air samples are obtained periodically in areas up to 2 miles downwind from the exhaust stack, where maximum ground level concentrations would be expected. During the entire year, air sample analyses revealed no detectable concentrations of tritium gas ($<1,300,00$ $\mu\mu c/m^3$ of air) or tritium oxide ($<5,000$ $\mu\mu c/m^3$ of air).

Water Sampling

A combined sewer effluent sample is obtained daily from beyond the perimeter of the plant's property. During the year, there were no detectable concentrations of radioactivity ($<120,000$ $\mu\mu c$/liter) in the 246 samples taken.

Surface water samples are normally obtained during the last week in each month at locations within 6 miles of the plant. These points are determined by radioactivity discharges in the exhaust stack effluent and meteorological data. In the event of accidental discharge of significant amounts of tritium, samples are obtained at the point of maximum ground deposition during or immediately following such discharges. There were no indications of tritium in 100 surface water samples analyzed during the year.

Milk Sampling Results

Fifty samples of raw milk were taken from farms within a 3-mile radius of the plant. These samples were analyzed by the Florida State Board of Health during 1962. No detectable concentrations ($<120,000$ $\mu\mu c$/liter) of tritium were evident.

Previous coverage in *Radiological Health Data:*

Period	Issue
1960–1961	*July 1962*

Reported Nuclear Detonations

May 1963

One nuclear detonation was announced by the Atomic Energy Commission for the month of May. This test, conducted underground on May 22 at the Nevada Test Site, was of intermediate yield. (The AEC has annouced the intermediate yield range as being from 20 kilotons to 1 megaton.) *Radiological Health Data* has assigned the test the arbitrary reference number of 103.